In This Issue: A 30-Mile Railway Tunnel Project Under the Cascades.

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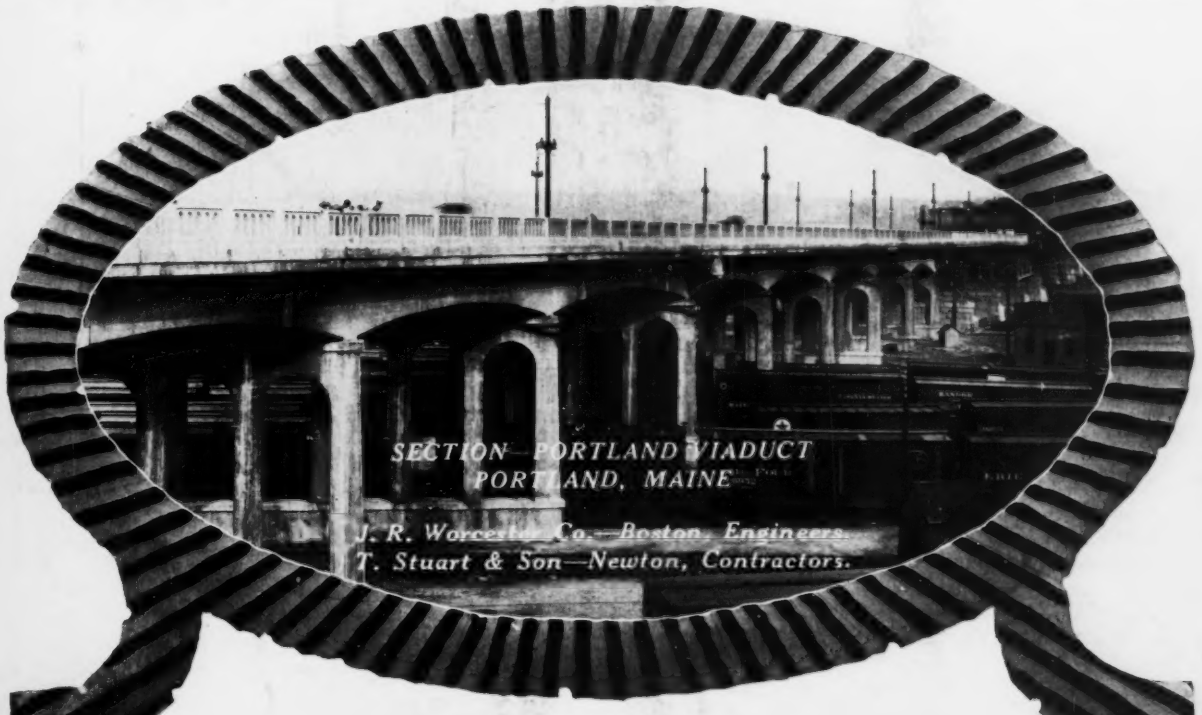

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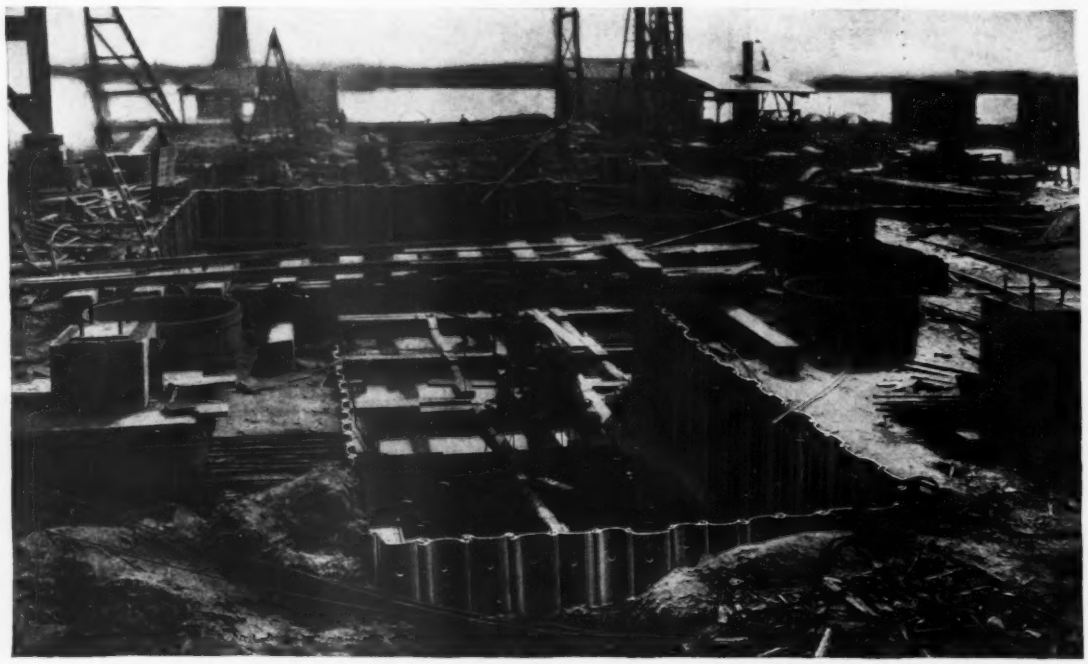

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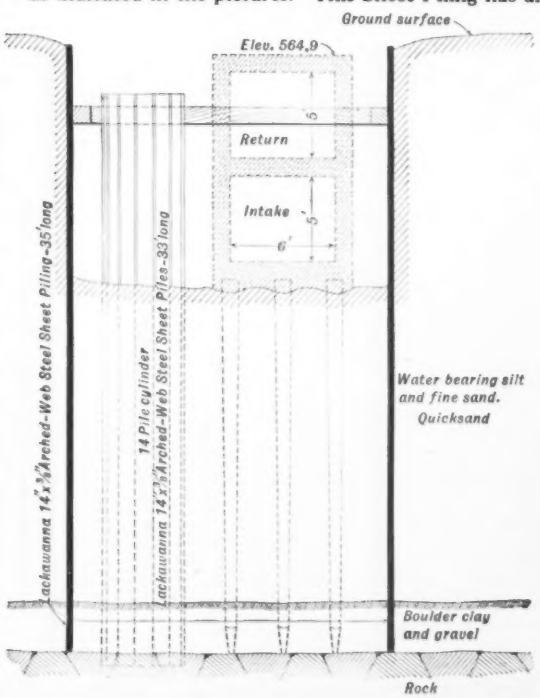

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Engineering News

VOLUME 76 NOVEMBER 16, 1916 NUMBER 20

Famous Yadkin Development Nearing Completion

The much exploited hydro-electric project at the narrows of the Yadkin River in Stanley County, N. C., is now approaching a completed reality, after 15 years of vicissitude and in the hands of the fourth interest that has undertaken its development. Here is rising a solid concrete dam about 1,400 ft. long, of 217 ft. maximum height and containing 525,000 cu.yd. of concrete. This is the highest overfall-type dam on record and one of the largest in its concrete yardage. In the power house immediately below the dam there are being installed three 31,000-hp. generating units (out of an eventual four) these being by a considerable margin the largest-capacity single-runner turbines yet built. The possibility of developing a great block of electric power at the gorge of the Yadkin River, some 30 mi. southeast of Salisbury, N. C., has long been attractive. The first recorded attempt at utilizing the fall was promoted by the late George Whitney, of Pittsburgh.

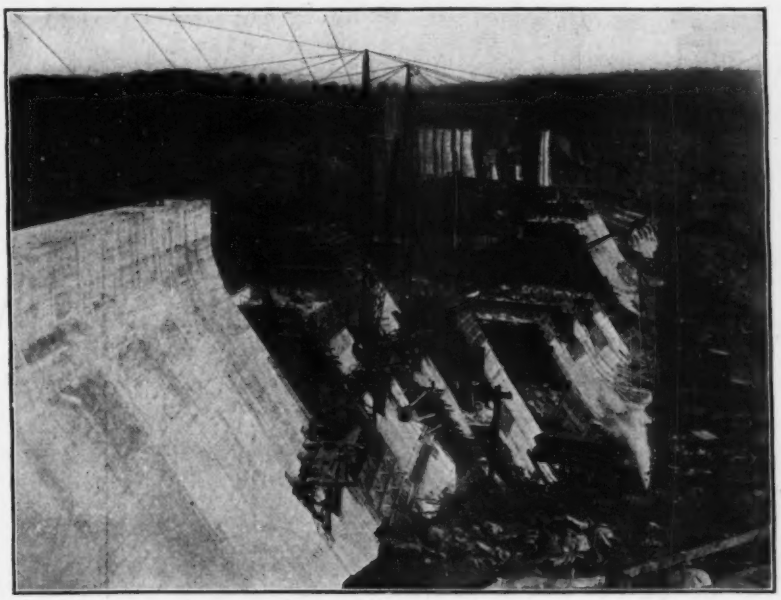


FIG. 1. THE YADKIN NARROWS DAM ABOUT NOV. 1, 1916

Before actual construction started, the project passed into the hands of the North Carolina Electric and Power Co., which created the town of Whitney and built a very long and expensive cut-stone dam at the head of a 5-mi. stretch of canal. This company was caught in the financial depression of 1907 and was taken over later by a French concern, the Southern Aluminium Co., which proposed to establish in that district a large aluminum industry. This company's plans for the development had been made on radically novel lines, and construction had progressed steadily (as described in *Engineering News*, June, 11, 1914) when the European War halted the work.

After about a year's interim the new town of Badin and the industrial site were purchased by the Tallassee Power Co., a subsidiary of the Aluminum Co. of America. Under the new owners the town has been further developed and is rapidly growing toward its eventual population of 5,000. The plans of the hydraulic development have been considerably changed again by the new owners and a practically completed power house and its equipment were abandoned; but the dam, so far as it was constructed, has been made use of.

General Plans of Present Development

The plans of the French engineers (that is, of the Southern Aluminium Co.) because of the features of novelty—judged from American standards—excited unusual interest in engineering circles. The old French plan, briefly reviewed, consisted of throwing a curved non-overflow gravity-section concrete dam about 1,350 ft. long and 200 ft. high (maximum) across a deep rock gorge, the creation of a reservoir covering about 8 sq.mi. of territory and the construction of a power station on the west bank immediately below the dam, housing sixteen 5,200-kw. direct-current and two 1,200-kw. alternating-current units. The effective head was to be 175 ft.

In connection with this dam there was to be no side canal or bypass, as commonly provided in American practice. There was, instead, a short overfall section with 10 control gates above the crest, at the east end of the dam, disposed in a curve around a bowl excavated in the hillside and drained by two big wells, 60 ft. in diameter, connecting with two bypass tunnels which were also to be used during construction to divert the river from its original course.

The changes made by the Tallassee Power Co. principally concern the conversion of the dam into an overfall section clear across the river, the use of a spillway bypass channel instead of wells and tunnels, the building of a new power house, the use of vertical-shaft turbines, and the generation of alternating current instead of direct.

The Tallassee Power Co. in order best to utilize the concrete placed in the dam by the French company, without accepting all the features of the layout, retained the idea of a curved dam of gravity section—making the main dam of overfall section along the entire length, except for about 450 ft. of wing at the west end and 100 ft. at the east end, increasing the base width and the area of cross-section and modifying various other details. The cross-section of the dam as now being built is shown in Fig. 4. In connection with this it should be noted that the weight of the cyclopean concrete is unusually great—162.5 lb. per cu.ft. This is due to the high specific gravity of the porphyry aggregate.

A new power station was built across the river and designed to house four 27,000-hp. single-runner vertical-shaft Francis turbines driving alternating-current generators. These are the largest-capacity single-runner wheels yet built. Only three units are to be installed at the present. The penstocks are of steel plate and come down from an intake section at the east end of the dam proper. Inclined stop-log grooves are provided in front of the trash racks of the intake, and motor-operated hoist-lifted Stoney gates will be installed—to be controlled from the power station.

There are 22 Taintor gates, 25x10 ft., placed between piers along the crest of the main length of dam west of the intake. From the intake a spillway section, with a lower elevation of crest, curves sharply away to the southeast. This section is about 44 ft. long over all and carries 10 Stoney gates, each of 33 ft. clear width between piers. The combined discharge capacity of the Taintor and Stoney gates is computed to be 250,000 sec.-ft.—or 90,000 sec.-ft. greater than the biggest flood flow of the last century.

The more important features of the Taintor gates are shown in Fig. 5. It is especially interesting to note that these 22 crest gates are operated by a single movable hoist that travels along the overhead bridge. This is an economical departure from the usual expensive practice of individual hoists for each gate. Each gate carries

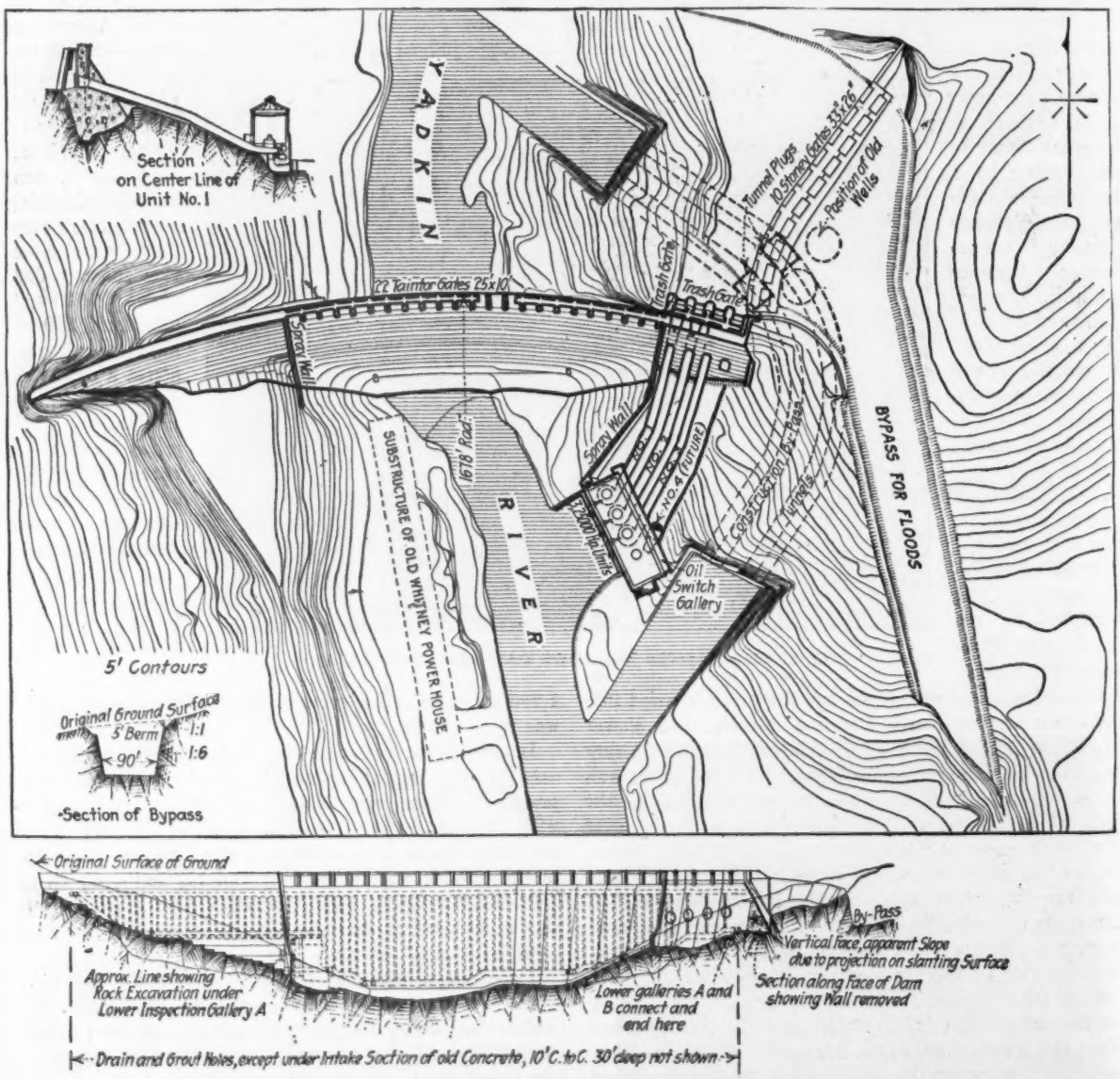

Section on Center Line of Unit No. 1
YADKIN
22 Taintor Gates 25x10
Trash Gate
Trash Gate
Tunnel Plugs
10 Stoney Gates 33'3"x76'
Position of Old Wells
Spray Wall
Spray Wall
SUBSTRUCTURE OF OLD WHITNEY POWER HOUSE
181' Road
RIVER
No. 4 (Future)
Construction Tunnels
BYPASS FOR FLOODS
27000 hp Units
Oil Switch Gallery
5' Contours
Original Ground Surface
5' Berm
1:1
1:6
90'
Section of Bypass
Original Surface of Ground
By-Pass
Vertical Face, apparent Slope due to projection on slanting Surface
Section along Face of Dam showing Wall removed
Approx. Line showing Rock Excavation under Lower Inspection Gallery A
Lower galleries A and B connect and end here
Drain and Grout holes, except under Intake Section of old Concrete, 10' C. to C. 30' deep not shown

FIG. 2. GENERAL LAYOUT OF YADKIN NARROWS DEVELOPMENT, TALLASSEE POWER CO.

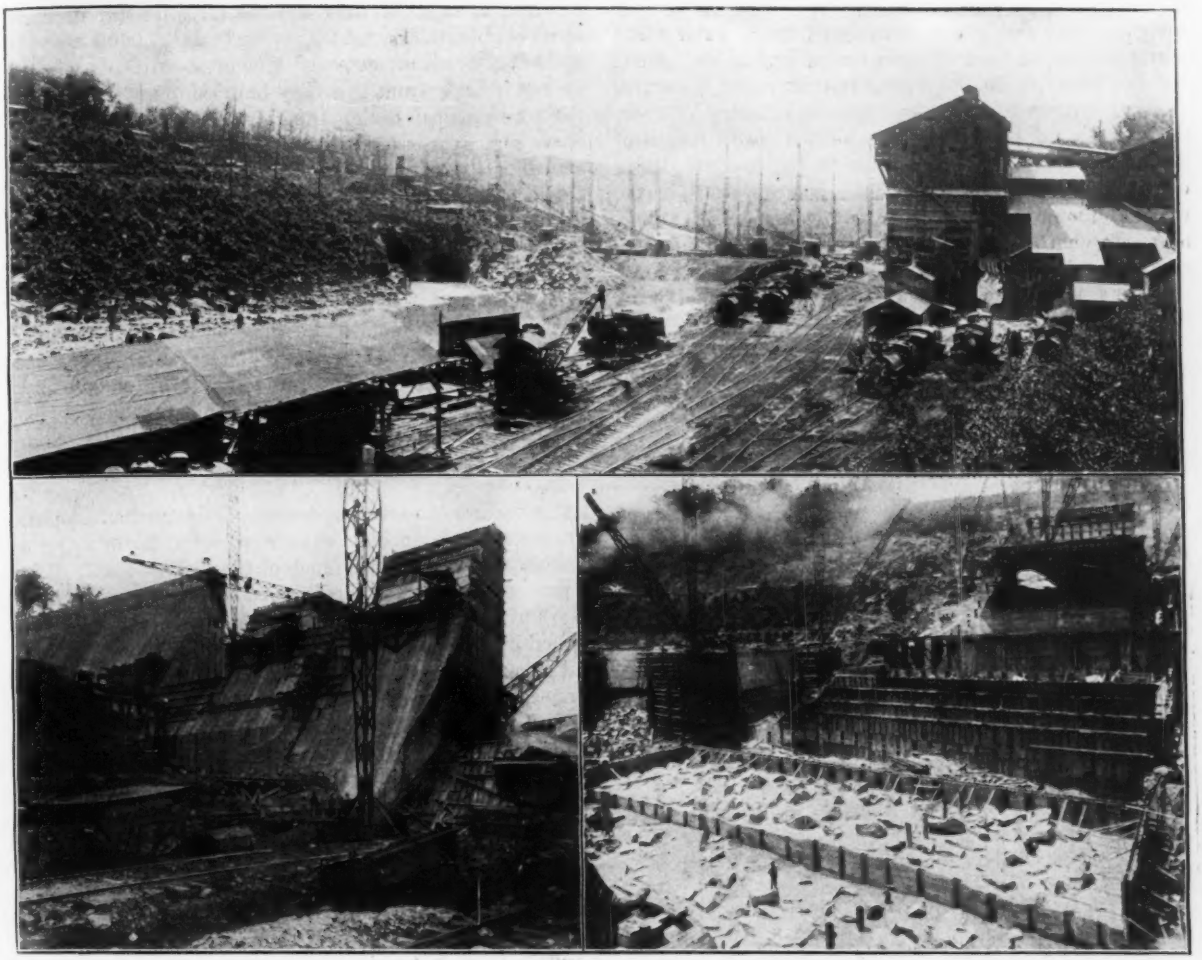


FIG. 3. VIEWS OF YADKIN NARROWS DAM AT VARIOUS STAGES OF WORK

Top—From upstream, showing conditions at about time Tallassee Power Co. took over the project. Lower Left—Showing spray wall at junction of overfall and high sections. Lower Right—Showing plums, drainage-tube forms, key joints, etc. Photographs by E. Jungerman, Columbus, Ga., photographer for the Hardaway Contracting Co.

two hoist chains, which are picked up by the traveling hoists for raising and lowering. The gate, when raised, is held up by dogs on the chains and bridge engaging, so that the hoist is freed for service. The bottom seal of the gate is a bolted-on plank with rubber-packing strip. The sides are sealed by a strip of rubber belting folded 90° longitudinally.

The bypass Stoney gates are also shown in Fig. 5. The design of gate and guides, it should be noted, was controlled by the dimensions of the concrete piers, which were partly built before the Tallassee Power Co. took over the project. The gate slots were already molded in the old piers, and this limited the treatment of gate ends. These Stoney gates are among the large ones in this country—though hardly approaching the largest built—and well illustrate the best-recognized practice of the day. They are 35 ft. wide, 26 ft. high, are horizontally framed structures with built-up horizontal girders and are open at the back. The downstream flanges of the flat horizontal girders are hung by channels from a top truss.

Each gate is lifted by a pair of permanently attached screws, the lower ends of which engage 3-in. pins in side plates at the upper gate corners. Each screw is lifted by a non-rising nut rotated through worm gearing by a 25-hp. motor. The details of guides, rollers and seals for the Stoney gates are shown in Fig. 5.

To provide contraction joints and to facilitate construction the dam is built in vertical blocks of about 50-ft. width, measured on the upstream face. One block was carried up several lifts before the adjacent one was started. The horizontal joints (marking a day's work) were allowed to come at the convenience of the contractor, but never closer than 5 ft. The concrete was continuously poured during each day's work, except where the inspection galleries were inclined.

The vertical faces of the blocks of the dam are marked with key grooves 2½ ft. wide and 4 ft. apart, as shown in Fig. 4. These are painted with coal-tar paint (1 pt. of kerosene to 1 gal. of tar) applied hot. This is to prevent all bond of concrete to concrete; and while there is no appreciable thickness to the tar coating, it sufficiently serves as a contraction joint.

Although the upstream cutoff trench was carried to sound tight rock, a line of 30-ft. drill holes on 10-ft. centers was put down in the ledge under the heel of the dam. These holes will be grouted from the lower upstream inspection gallery. Eighteen-inch drain holes, on 10-ft. centers, were cored in the concrete to rock under the downstream gallery; from the bottom of these drain holes,

40-ft. holes were drilled into the ledge—and left open to serve as drains and thus prevent uplift due to water which may percolate past the line of grouted drill holes. Along the dam and 7 ft. below its crest runs an upper inspection gallery, connected to the lower upstream gallery by 18-in. drain holes, on 12½-ft. centers for the entire length of the dam. These holes were cored in the concrete, using collapsible steel forms. The drain-hole openings in the upper and lower galleries are covered by cast-iron gratings.

As the dam is curved (radius 1,678 ft.) and the piers supporting the gate-operating bridge are on radial lines, the piers were tapered so as to provide parallel walls for each gateway.

The spillway apron, formed by the downstream face of the main dam, is dished toward the downstream corners,

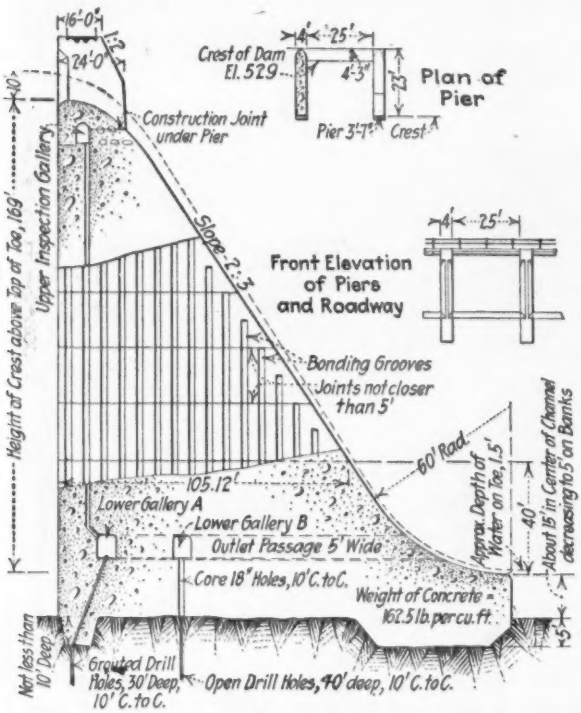

16'-0"
24'-0"
Crest of Dam El. 529
4'
25'
4'-3"
25'
Plan of Pier
Construction Joint under Pier
Pier 3'-7½"
Crest
Upper Inspection Gallery
Height of Crest above Top of Toe, 169'
Slope 2:3
Front Elevation of Piers and Roadway
Bonding Grooves Joints not closer than 5'
60' Road
105.12'
Lower Gallery A
Lower Gallery B
Outlet Passage 5' Wide
Core 18" Holes, 10' C. to C.
Weight of Concrete = 162.5 lb. per cu. ft.
Approx. Depth of Water on Toe, 15'
40'
About 15' in Center of Channel decreasing to 5' on Banks
Not less than 10' Deep
Grouted Drill Holes, 30' Deep, 10' C. to C.
Open Drill Holes, 40' deep, 10' C. to C.

FIG. 4. MAXIMUM SECTION, YADKIN NARROWS DAM

so as to form a bucket that shall guide the overflowing water toward the river channel. The apron is separated by spray walls from the non-overflow section on the west end and from the penstocks and power house on the east end.

Unusual Features of Power Station

The power station, for many reasons, is one of the most interesting built in recent years. By generating at the transmission voltage (13,200) no station transformers are required, except for the building services. This greatly simplifies the switching layout, and the effect is increased by using outdoor type of main oil switches on a gallery outside the generating station. Fiber conduits carry the conductors from the generators to the oil-switch terminals.

The remarkably steady load to be furnished by the nearby aluminum works permits an efficient use of very large generating units—larger than is commonly desirable in general practice. Each turbine will develop 27,000 hp. at maximum efficiency and 31,000 hp. at full gate, so that in point of capacity these are the largest hydraulic turbines ever built. Each turbine drives an 18,000-kv.-a. 36-cycle 1,320-volt three-phase generator with its exciter on top. Aside from this they have points of interest in their mechanical design, notably the use of steel-plate scroll casing embedded in concrete and a scheme of dismantling the runner from below, as described more in detail in another article. The runner diameter is 108 in.; the speed, 154 r.p.m.; and the head, 165 to 180 ft. The casing inlet is 12 ft. in diameter, and a tapering thimble connects to the 15-ft. penstocks. The upper part of the draft tube is of cast iron and telescopes into the section below, which is molded in the concrete substructure. The draft tube is 11 ft. in diameter at the top, but immediately begins to flare; and it flattens as it makes the usual right-angle turn, the outlet being 32 ft. wide by 13 ft. 3 in. high.

Dismantling Turbine

One feature of particular interest is the method adopted for removing a turbine runner without disturbing its generator or dismantling much of the turbine itself. The upper section of the draft tube telescopes downward exposing the runner which can be lowered on a spider carried by a cable running up through the hollow turbine and generator shafts to the main station-crane hook. The runner, once clear of the shaft, is lowered upon a service car and shoved out through an adit between the draft-tube chamber and a longitudinal tunnel 11½ ft. wide and 8½ ft. high. Tracks in the latter allow the runner to be carried on a car to a hatch, up through which it is lifted by the main-station crane and carried to the railway connection in the south end of the building.

Above the runner-shifting tunnel is a second and smaller longitudinal tunnel (9 ft. wide and 10 ft. high) that serves two purposes. It gives access through a manhole to each turbine scroll case, and it also serves as the exhaust duct for the cooling air from the generators. Four 3x4-ft. passages come down from each generator into the tunnel. The tunnel terminates at each end in a vertical 11-ft. well whose top is outside the building. The generators are inclosed in air-tight sheet steel cases and act as their own fans, drawing cool air in from the generator room, which is replaced by air coming through the roof monitor, and forcing it through the tunnel and wells. The upstream air well can be protected from extreme high water by a timber and steel cover.

A control gallery, about 13x20 ft. in plan, projects out into the generator room from the east wall of the station. It is 10 ft. above the generator-room floor. From it, steps lead up to the switch-gallery door and down to the generator floor. A continuous steel platform runs from unit to unit at the control-gallery level and provides a walkway around each thrust bearing, so that attendants may pass from one machine to another without descending to the main floor. The generator-room floor will be of concrete, in 6-ft. squares with troweled joints.

The superstructure of the station is a steel frame with brick curtain walls rising 40 ft. above the substructure, which itself has foundation walls rising 18 ft. above the generator-room floor, to provide for flood conditions. The steelwork of this structure is material taken over from the original station superstructure, now dismantled. The columns have been reinforced with channels, etc. A pumphouse to supply the town and works with water, is located at

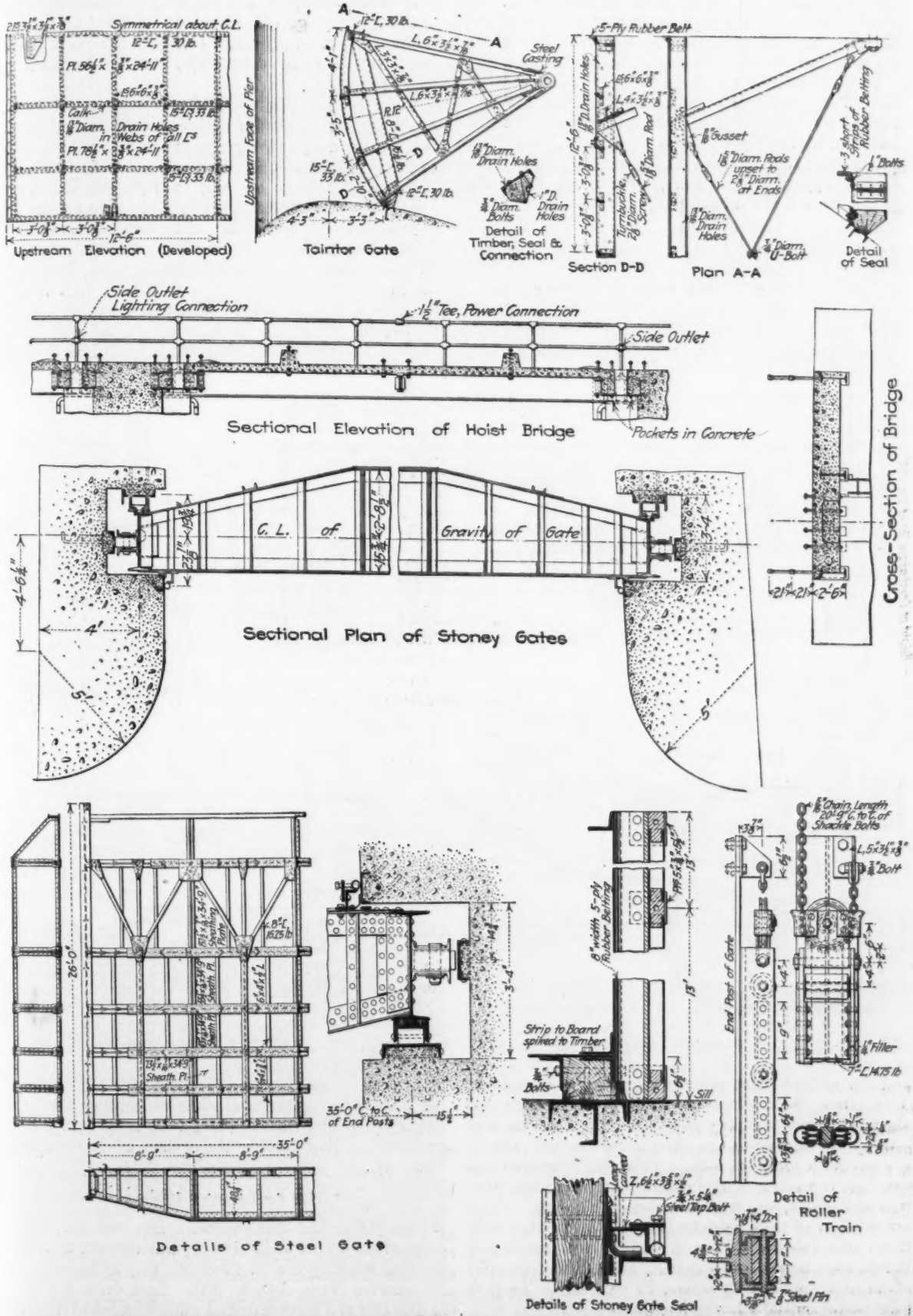


FIG. 5. DETAILS OF TAINTOR AND STONEY GATES, TALLASSEE POWER CO., YADKIN RIVER DEVELOPMENT

the south end of the building next to the air well. The power house is 213½ ft. long over all and 76 ft. wide. Under the railroad siding in the south end of the generator room are the lockers, shower, toilet and battery room.

The penstocks are 15 ft. in diameter and from 270 to 370 ft. long. They are made of steel plate, the thicknesses varying by 11 steps from ⅜ to ¾ in. They are anchored at the top in the dam and below this in the power-house substructure. In between they rest on steel saddles supported by concrete piers, and are free to slide as they expand or contract.

On the Contractor's End of the Yadkin Development

The most striking things about the Yadkin work, as a construction job, perhaps are the large number of unusually high, steel, guyed derricks used for handling material and the multiplication of railroad tracks to serve them. This arrangement affords not only great capacity, but almost complete flexibility also—blocking of one track or a delay or accident to one derrick reduces the capacity of the outfit only a little. This job illustrates the well-known practice of this contractor in the multiplication of derricks, which marks most of his work. There are in all 47 of these derricks—all built by the American Hoist and Derrick Co.—with 115-ft. steel masts and 100-ft. steel booms. One derrick has a lifting capacity of 50 tons; and the 46 others, 20 tons each. There is here used about 60 mi. of guy cable.

All the hoist-engine and swinging-gear units for these derricks are alike—a somewhat special Lidgerwood outfit with 9x10-in. tandem engines, steel gears, extra-heavy swinging-gear drumshafts, and double brakes on both drums.

These engines have been adopted as standard by the contractor for his derrick work generally, as this simplifies maintenance, and has resulted in always having the enginemen familiar with every hoisting outfit on the job. The engines are run on compressed air supplied at 100 lb. gage. Each branch line to each engine from the distribution lines has a small iron coil inserted, and in this the enginemen keep a small wood fire on cold days and early mornings to prevent frost causing trouble in the engine exhaust.

There are two compressor plants on the work, housing electric-driven machines having a total capacity of 13,200 cu.ft. of free air. The main plant is located on the west bank, near the dam. A smaller plant is placed at one of the downstream quarries about a mile below the dam. Electric power for construction service is brought in by a transmission line tapping the system of the Southern Power Co.

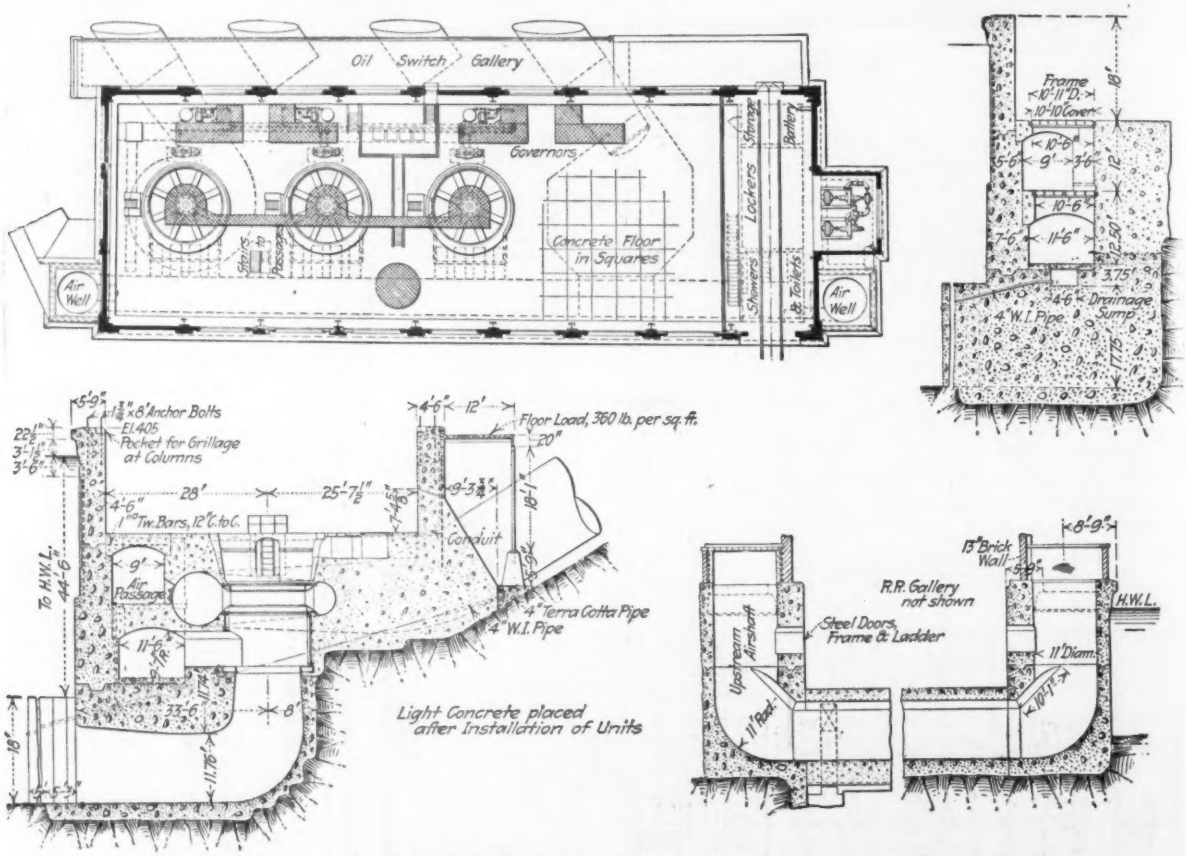


FIG. 6. PLAN OF YADKIN NARROWS POWER HOUSE, STANLEY COUNTY, NORTH CAROLINA

Use of Largest Mixers

This job is the one on which are used the largest concrete mixers yet built—two 4-yd. units built especially for this work by the T. L. Smith Co., as described in *Engineering News*, Apr. 6, 1916. Each drum is 9½ ft. in diameter and is supported on a structural-steel framing.

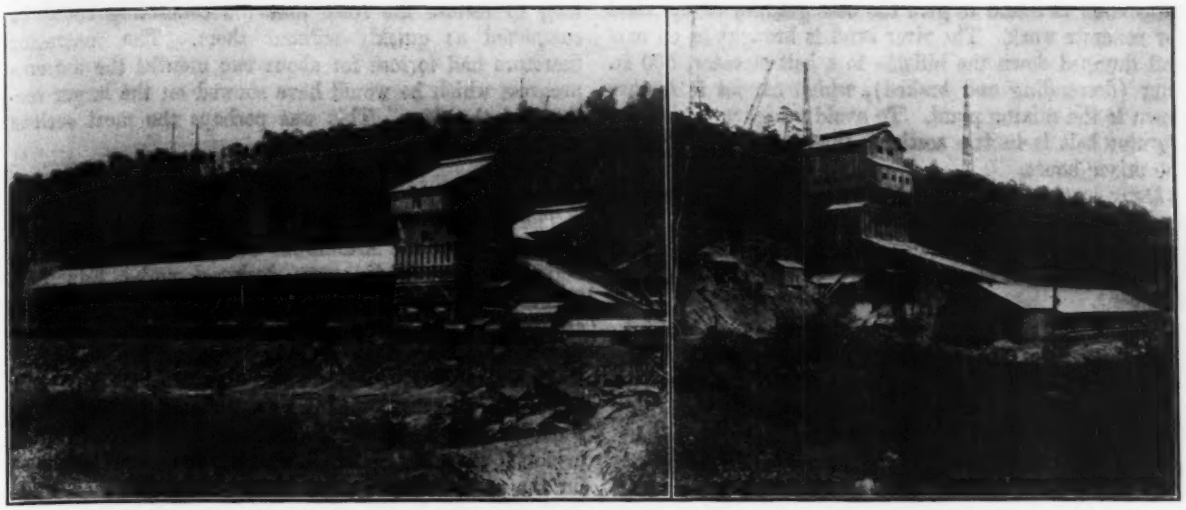


FIG. 1. CRUSHING AND MIXING PLANTS OF THE HARDAWAY CONTRACTING CO. ON YADKIN RIVER WORK
Left—Upstream plant and cement storage. Right—Downstream plant

The great gain through the use of these mixers comes from the concentration of capacity in two working units instead of distributing it over four. The desire here was to retain the simple plant with two mixers and one railway track but turning out about 50% more concrete than the four-mixer two-track layout. The mixers are run on 3-yd. batches instead of being pushed to capacity. There has been a gain by the concrete trains getting away quicker, and the load being taken off quicker at the dam so that the train can return sooner. The derricks also have to make only two-thirds the number of movements to place the concrete.

On this job there are two mixing plants, one upstream from the dam (four 2-yd. cube mixers, each pair discharging to separate tracks) and one downstream (with two 4-yd. mixers). The output of each has been about 1,080 cu.yd. on an ordinarily good day. The upstream concreting plant has cement storage for 40,000 bbl. All cement is brought in sacks and chiefly from Southern mills. At the end of the cement shed is the crushing plant. Stone is brought in on tracks from upstream and passes in order through a 64x42-in. jaw crusher, a No. 10 gyratory, four No. 6. gyratories, and then goes to a 2½-in. revolving screen. The rejections are returned to a pair of special No. 6's—fitted with No. 5 throws for finer crushing. A $\frac{5}{16}$-in. jacket on the screen takes out the sand, which goes with the material under $\frac{5}{16}$ in. from the first screens to the sand pile. Stone under 2½ in. is elevated to the mixing-plant bins. A No. 21 Gates gyratory is also installed for use in case the jaw or No. 10 is out of service because of repairs or otherwise.

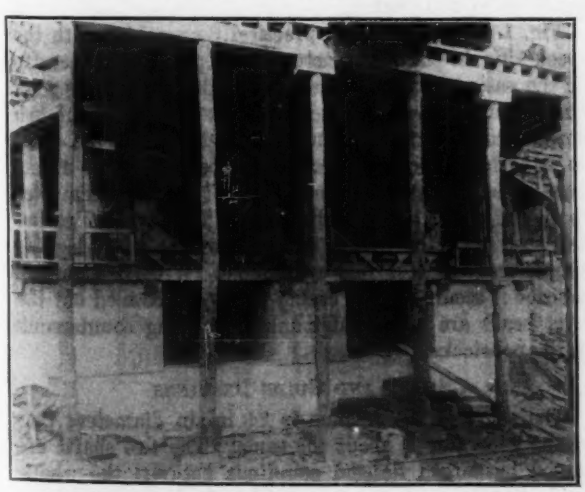


FIG. 2. THE TWO 4-YD. MIXERS INSTALLED ON YADKIN WORK

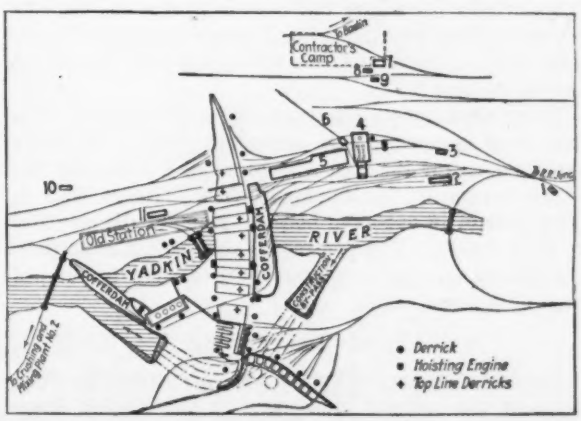


FIG. 3. LAYOUT OF HARDAWAY CONTRACTING PLANT BEFORE FLOODS
Not to scale. 1—Wood shop. 2—Machine shop. 3—Supply house. 4—Crushers and mixers. 5—Cement storage. 6—Sand conveyor. 7—Commissary. 8—Transformer house. 9—Compressor plant. 10—Tallassee Power Co., engineer's office. 11—Machine shop. Topline of derricks placed later.

The downstream mixing plant has but small cement storage, the shed serving more as a transfer depot between the car and mixer house, to which the cement is elevated on a belt conveyor. Stone is brought in from three downstream quarries and passes through an 84x60-in. jaw crusher, two No. 8's and then over 2½-in. screens. The stone between $\frac{5}{16}$ and 2½ in. going through is elevated to the bins, while the rejections go to two No. 6 gyratories and an elevator. A portion of the stone between $\frac{7}{16}$ and 1 in. goes to sand rolls and screens and finally to sand bins.

The sand used at both concrete mixing plants is washed Catawba River sand, mixed with 26 to 28% of crusher sand, the latter running from $\frac{5}{16}$-in. size to dust. This

proportion is found to give the best grading of the sand for concrete work. The river sand is brought in on cars and dumped down the hillside to a belt elevator, 500 ft. long (descending and braked), which carries it farther down to the mixing plant. To avoid a higher trestle, the elevator belt is in two sections, the second ascending to the mixer house.

Daily tests of sand, cement and concrete are made in a well-equipped field laboratory. The cement tests, however, are few and only checks, as the cement is tested by an independent commercial-laboratory company before shipment.

At first a 1:3:5 mix was used; but as studies into sand, aggregates and concrete were continued, this was changed to 1:2½:5, which gives the best and strongest concrete. The concrete is unusually heavy, weighing 162½ lb. per cu.ft. This is due to the high specific gravity (2.92) of the local porphyry rock used as aggregate and crusher sand. About 25% of displacers are used in the concrete, these varying from 1 to 4 cu.yd. in size.

In excavating the porphyry, sharp shots of 60% nitroglycerin dynamite are used. The hardness of this rock causes heavy expense for maintenance of mixing machinery. Screens last only about two weeks; elevator-bucket bolt heads are cut off in about 10 days; mixer linings and sheet-steel plates last but little longer.

The contractor employs about 2,000 men, including 350 convicts, for whom the state is paid a specific sum per man (fixed by bidding) and provides quarters, meals, guards, etc. These convicts are engaged on quarrying, excavating and filling.

Three-room houses are provided for the married foremen, hoist enginemen and carpenters. Two-room houses are provided for the men who board at a mess hall run by the contractor for unmarried labor. Negro labor is taken care of in one-room houses. None of the men live in bunk houses. The contractor also maintains a large commissary store. The water for the camp is pumped from deep bored wells.

Floods Delay Work

The work of the contractor was interrupted in July, 1916, by the extreme high water in the Yadkin River prevailing at the time of the phenomenal rain in that region. The flow reached 160,000 sec.-ft. in round numbers, and the river rose above the tracks and coffer-dam. The end of the upstream coffer-dam was carried away by the flood, and its downstream side was damaged by the overflow. The downstream cover was very largely carried away, parts of the stone cribbing remaining, however. A portion of the outer wall of the old power-station substructure fell out, owing to the pressure of the wet fill inside. All the slabs, wells and tunnel on the dam were lost. Two derricks were carried away upstream at the face of the dam, and three downstream below the dam. Practically all the railway tracks for 300 ft. upstream of the dam and 600 ft. downstream were carried away.

In rebuilding the construction work, the coffer-dams were replaced upstream and downstream as before, and the upstream tracks were replaced in practically their original position.

Few of the downstream tracks were replaced, although without them only half the designed rate of progress in concreting could be secured. It would have taken so long to restore the lines that the concreting could be completed as quickly without them. The contractor therefore had to lose for about two months the extreme progress which he would have showed on the larger sections of the dam. This was perhaps the most serious effect of the flood.

Engineers and Contractors

The Tallassee Power Co., making this development, is a subsidiary of the Aluminum Co. of America. All the main works at Badin were designed under Edwin S. Fickes as Chief Engineer and G. F. Murphy as principal assistant. The complete plans for the electrical installation were elaborated by William Hoopes, Chief Electrical Engineer, and T. J. Bostwick, his principal assistant. The hydraulic development was designed by James W. Rickey, Chief Hydraulic Engineer, and C. B. Hawley, his principal assistant. J. E. S. Thorpe, as resident engineer for the power company, has charge of construction work at Badin. He is directly in charge of the work at the dam site. The work on the industrial plant and town of Badin is under the immediate supervision of R. R. Stevenson.

The Hardaway Contracting Co., of Columbus, Ga., is the contractor for all the work at the vicinity of the dam. The contract for the bypass excavation channel was sublet to Rinehart & Dennis, of Charlotteville, Va. The hydraulic turbines and related equipment were built by the Allis-Chalmers Manufacturing Co., of Milwaukee. The generators and exciters were from the General Electric Co., of Schenectady, N. Y.

Three 31,000-Hp. Turbines for Yadkin Plant

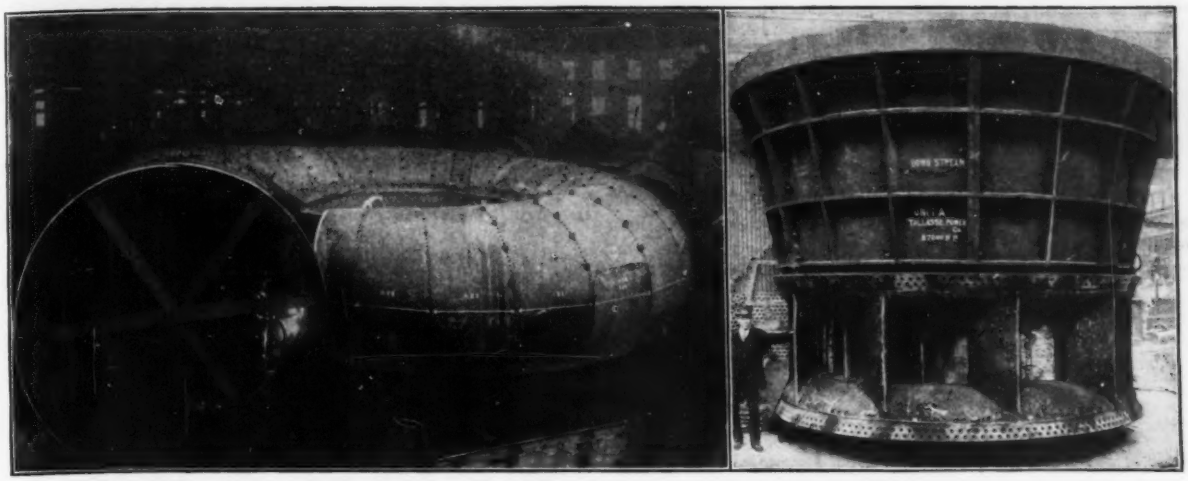
The three turbines built for the initial installation of the Tallassee Power Co. at its Yadkin River development in North Carolina (described in the preceding articles) are by far the largest single-runner Francis turbines yet built and show features of unusual interest and novelty, aside from size, particularly in the steel-plate spiral casing and the provision for dismantling the runner.

The spiral casing for each unit is of circular section and is made of shaped steel plates riveted together and to a cast-steel speed ring delivering the water to the guide vanes and runner.

Fig. 1 shows the casing practically assembled with the speed ring in the manufacturer's shop. The immensity of the casing can be realized from the size of the man inside the entrance. The casing is formed by about two dozen conical sections, each one matching into the other so as to form a continuous smooth passage. The thickness of the plate varies from ⅞ in. at the large diameter to $\frac{7}{16}$ in. at the smallest diameter. This type of casing has been patented by the manufacturers; the design is simple and the cost very reasonable. With it a smooth interior is secured. The casing joints are beveled but the rivet heads are not countersunk—not being countersunk in the penstocks.

Shaft and Guide Bearings

The shaft of the turbine is 24 in. in diameter; that of the generator is about the same. The two shafts are joined by forged flanged couplings between the wheel-guide bearing and generator. The flanges are made of larger diameter than usual, and the bolts are much heav-



FIGS. 1 AND 2. STEEL-PLATE SPIRAL CASING, CAST-STEEL SPEED AND UPPER SUPPORTING RINGS OF 31,000-HP. TURBINES

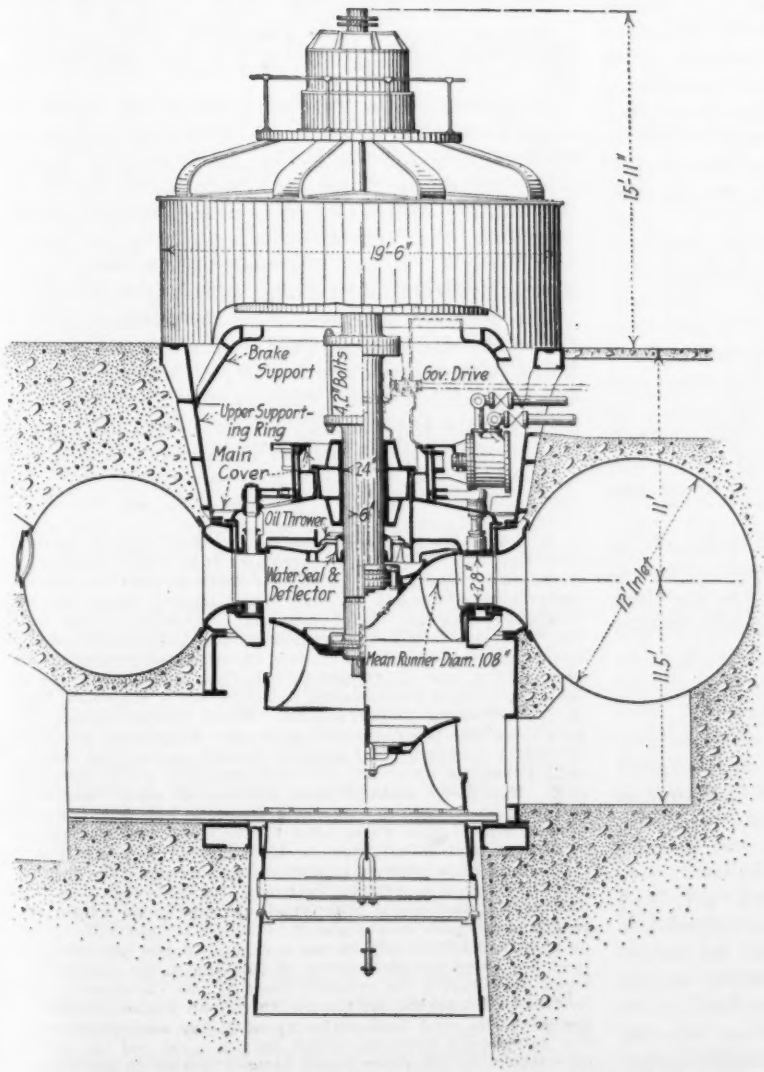


FIG. 3. SIMPLIFIED SECTION THROUGH TALLASSEE TURBINE UNIT, SHOWING SCHEME OF DISMANTLING RUNNER

ier than necessary to transmit the torque, the heavy bolting being necessary in order to make the shaft substantially as strong in bending at the flange as at other points. The shafts of both waterwheel and generator are hollow, to facilitate inspection of the forging and to permit handling the runner and upper section of the draft tube by means of a cable passing through the center of the shaft to the hook of the main station crane. The waterwheel and generator are designed as a mechanical unit, so that the lower guide bearing usually furnished with a generator is omitted; the machine, then, is what may be called a "two-guide-bearing unit." One guide is located above the rotor of the generator, immediately under the thrust bearing. The large guide bearing of the turbine serves as the lower guide bearing for the generator, as may be seen in Fig. 3. The guide bearing on the waterwheel is a babbitted casting with 48-in. shaft face, oil lubricated. It is supported in a conical seat of the main cover plate, which also carries the shifting ring and the guide-vane shafts. Oil is forced in through a pipe line and a flow meter is fed to the top of the guide bearing. The housing cover has an overflow pipe to the oil drain below the bearing. The oil is prevented from being drawn into the shaft tube by providing a large oil-throwing ring on the shaft between the lower end of the bearing and the oil drain. The elevation of the oil catcher from the turbine guide bearing is sufficiently high so that the oil drains horizontally over the top of the distributor plate and is led down through one of the vanes of the speed

ring to a sump tank below the level of the spiral casing. A short pipe connection with union joints connects the oil passages in the main cover plate and the speed-ring casting, and between the speed ring and the sump. Below the oil thrower is a double water seal with air vent between, and grease-lubricated shaft rings.

The total weight of the revolving parts and the reaction thrust of the loaded runner are carried by a Kingsbury thrust bearing. The total weight of the various revolving parts is as follows:

Turbine shaft	18,000 lb
Runner	20,000 lb
Generator and exciter rotor	146,000 lb
Hydraulic thrust	60,000 lb.

The weights of the various stationary parts are as follows:

Stators and bridge	142,500 lb.
Upper supporting ring and brake ring	80,000 lb.
Spiral casing and cover plates	160,000 lb.
Lower supporting ring	40,000 lb.

The turbine runner, weighing 20,000 lb., is a single piece of solid bronze and is probably the largest casting of the kind ever made.

Each guide vane is supported upon an oil thrust bearing placed just underneath the guide-vane lever so as to maintain the guide vane in central position and avoid friction at each end of the vane. To keep the guide vane from bearing on the upper distributor ring, due to the water pressure in the casing, a collar is provided below the upper vane bearing. The connection between the guide-vane levers and the shifting ring is such that adjustment can be made on any vane that may have become distorted.

A brake support has been provided, consisting of a heavy cast cone fitted into the upper supporting ring between the waterwheel and the generator. This casting has openings permitting inspection of the windings on the rotor of the generator from the turbine pit. These openings, however, have sliding doors so that when they are closed the cone forms a partition between the generator and the wheel pit, preventing the hot air from the generator from being driven down into the turbine pit before it is led off to the exhaust tunnel in the station substructure.

The governor is essentially the standard design of the wheel manufacturer, in which fly-ball actuated valves control the admission and discharge of oil to two operating cylinders ("servomotors") that have piston rods running to the shifting ring.

Capacity and Efficiency

As the head available for the operation of these units will vary considerably, two guarantees of output at given heads were made. Each unit is designed to deliver to the generator shaft not less than 27,000 hp. when operating under an effective head of 165 ft. and running at a speed of 154 r.p.m. Under these conditions it is to develop an efficiency of not less than 90.5% (efficiency being defined as ratio of water horsepower delivered to the unit to mechanical horsepower output at the turbine shaft). Each unit also is guaranteed to deliver not less than 31,000 hp. operating under an effective head of 180 ft. and at 154 r.p.m. A 36-in. model runner was constructed and tested at Holyoke, having dimensions homologous to those of the large design. Extracts from the Holyoke tests are appended. An efficiency of practically 91% was shown, and it is expected that this will be exceeded in the large units by a wide margin.

HOLYOKE FLUME TESTS OF YADKIN TURBINES

(Extracts from report of tests of 36-in. R. H. Allis-Chalmers turbine wheel, Test 2446, made Mar. 18 and 20, 1916; swing gate, conical draft tube.)

Proportional Opening of Speed Gate, In.	Part Full Discharge	Head on Wheel, Ft.	Speed of Wheel, R.P.M.	Relative Velocity Based on 36-In. Diameter	Water Discharged, Cu.Ft. per Sec.	Power Developed, Hp.	Efficiency of Wheel, %
3.000	1.002	17.32	143.67	0.676	67.55	109.89	82.82
3.000	0.998	17.37	148.00	0.696	67.41	110.48	83.20
3.000	1.000	17.31	158.00	0.744	67.41	111.18	84.02
2.750	0.959	17.11	146.00	0.691	64.25	107.20	85.99
2.750	0.955	17.08	153.25	0.726	63.98	107.84	87.01
2.750	0.950	17.10	158.00	0.748	63.64	106.35	86.17
2.500	0.908	17.40	146.50	0.688	61.40	107.57	88.78
2.500	0.903	17.41	151.50	0.711	61.06	107.53	89.20
2.500	0.895	17.44	157.00	0.736	60.59	105.67	88.18
2.125	0.799	17.80	155.25	0.721	54.64	99.75	90.43
2.125	0.796	17.79	163.00	0.757	54.38	99.74	90.91
2.125	0.793	17.95	167.50	0.774	54.44	100.44	90.63
2.060	0.782	16.60	151.80	0.730	51.61	88.24	90.82
2.060	0.780	16.86	154.50	0.737	51.87	89.81	90.56
2.060	0.779	16.59	154.50	0.743	51.42	87.92	90.88
2.000	0.775	17.70	149.00	0.694	52.83	95.73	90.27
2.000	0.769	17.70	156.50	0.729	52.44	95.76	90.97
2.000	0.767	17.75	159.50	0.741	52.38	95.65	90.71
1.875	0.738	17.87	148.60	0.688	50.53	92.75	90.57
1.875	0.735	17.85	154.25	0.715	50.28	92.50	90.87
1.875	0.729	17.86	158.00	0.732	49.90	90.88	89.92
1.750	0.690	17.90	149.40	0.692	47.27	85.93	89.55
1.750	0.689	17.84	149.75	0.694	47.15	85.22	89.33
1.750	0.685	17.92	153.75	0.711	46.96	85.61	89.71
1.375	0.560	16.80	130.75	0.625	37.17	60.00	84.73
1.375	0.555	16.71	138.75	0.665	36.77	59.43	85.29
1.375	0.541	16.54	151.50	0.730	35.68	56.55	84.49
1.000	0.420	16.89	117.25	0.559	27.98	43.05	80.32
1.000	0.413	16.90	124.50	0.593	27.51	41.90	79.47
1.000	0.408	16.91	132.75	0.632	27.20	40.61	77.86

Turbine and dynamometer carried on ball bearings. Weight of dynamometer and that portion of shaft above lowest coupling, 2,600 lb. With flume empty a strain of 0.5 lb. applied at distance of 3.2 ft. from center of shaft sufficed to start wheel.

The generators for these units are 28-pole 13,200-volt machines rated at 18,000 kv.-a. They have, however, an overload guarantee of 22,500 kw. (at unity power factor). The efficiency at 18,000 kw. (unity power factor) is 96.9%. The stator is 19 ft. 6 in. in diameter, and the rotor 14 ft. 9 in. The rotor flywheel effect (WR^2) is approximately 4,000,000. The weight of the rotors given above includes that of the bridge between generator frame and exciter. The latter is a 72-kw. 250-volt machine.

These turbines were designed, built and installed by the Allis-Chalmers Manufacturing Co., of Milwaukee, under direction of W. M. White, Manager and Chief Engineer of the Hyrdaulic Department. The generators and exciters were furnished by the General Electric Co., of Schenectady, N. Y.

A Water-Works Rate Decision holding that a dentist's revolving bowl is not a machine and that water supplied to it should be charged for under the domestic and not the industrial schedule has recently been handed down by the Westminster County Court, England. According to the London "Surveyor": "The plaintiffs were the Metropolitan Water Board, and they sought to recover £3, being the charge for six years at the rate of 10s. per annum, from a dentist for water used for alleged nondomestic purposes for a revolving bowl at the side of the patient's chair. Water was, of course, also used from this tap for washing out the mouth and the usual antiseptic purposes. The surgery formed part of the defendant's house, on which the ordinary domestic water rate was paid. The board claimed that this use of water was nondomestic under Sec. 25 of their Charges Act, 1907, on the ground that it was 'water used for working any machine or apparatus, and in addition or alternatively because it was water used for a trade, manufacture or business. The learned judge delivered a written judgment to the effect that, although the mechanical contrivance perhaps came within one of the dictionary meanings of machine, it was not, in his opinion, a machine within the meaning of the act, nor was the water used for the purpose of working it, the contrivance being used merely for sanitary reasons. On the second point he held that washing out the mouth was an ordinary domestic use of water, and that, although such use was ancillary to the defendant's business, which indeed could not be carried on without it, his honor found himself unable to distinguish the case from that very far-reaching decision of the House of Lords in the case of the Metropolitan Water Board vs. Avery, 1914, A.C., 118, and gave judgment for the defendant."

Change from Alum to Iron at Clarksburg Water Filters

By Perkins Boynton*

The substitution of sulphate of iron for aluminum sulphate at the filtration plant of the Clarksburg, W. Va., water-works has greatly reduced the war-time cost of coagulant and yielded some other noteworthy results.

The water-supply of Clarksburg is taken from the West Fork of the Monongahela River and is purified by coagulation and sedimentation, mechanical filtration, and sterilization by hypochlorite of lime. The plant was designed by George W. Fuller, of New York, and the filters were equipped by the New York Continental Jewell Filtration Co. The capacity of the filter plant is 3,000,000 gal. per day with four filters, a coagulating basin of 600,000 gal. and a clear-water well of 200,000 gal. The filter plant was put into operation in November, 1911 (the pumping station had been running since 1888), with sulphate of alumina as the coagulant and with the use of lime when necessary to increase the alkalinity of the river water. The river before reaching the water-works flows through a clayey, limestone region and is contaminated by mine wastes.

Last winter the greatly increased price of sulphate of alumina led the Water Works and Sewerage Board, under the advice of S. G. Highland, superintendent, and the writer to make a trial of sulphate of iron and lime to coagulate the water. The American Steel and Wire Co. through its Chicago office courteously supplied, free of charge, the sulphate of iron for the trial run and sent its representative, E. V. Wintzingerode, to assist the writer in the experimental work.

The original design of the filter plant does not include a mixing chamber, but provides that the chemicals be pumped into the low-lift line, carrying the water from the river to the coagulating basin, the lime entering the line about 50 ft. ahead of the alum. No trouble has ever been experienced in obtaining a good floc with alum. The same general plan, with the substitution of iron for the alum, also produces a good floc as soon as the water flows into the basin over the weir. A secondary treatment, with iron only, is possible just as the water enters the second half of the basin, so that any considerable amount of fine material passing through the first half of the basin is coagulated by this second dosage, sufficient lime being introduced into the water at the outset to allow for this.

During the two weeks of the trial run, there were several days of low turbidities (10 parts) and two periods of high turbidities, one including a turbidity of 1,500 parts. These covered all conditions, as far as turbidity was concerned, that had been met with heretofore. The smallest amount of iron used was 0.4 grain per gal. and the largest, 8.4 grains.

The conclusions drawn from the trial run were that a clear sparkling effluent can be obtained at all times, with original turbidities varying as stated, by the use of the same amount of iron as of alum. The results in the last six months have borne out this conclusion. The comparative costs of the two coagulants—iron, including the use of lime all the time, and alum, using lime when necessary—were $5 and $13 per million gallons.

*Chemist-in-Charge, Clarksburg Water-Works, Clarksburg, W. Va.

Several interesting facts have been brought out since the use of iron and lime was begun. When the first water treated with iron and lime reached the filters, the loss-of-head gages began to show a decrease in the loss of head instead of an increase. The curve continued to drop for two or three hours and recorded a loss of head from 1 to 1½ ft. less than when the drop began, then began to rise normally again. This was explained as follows: The filters were saturated with free CO_2, although never having shown that they were "bound" by it; and this CO_2 was absorbed by the normal carbonates in the water, 10 to 20 parts of phenol alkalinity being carried by the water upon reaching the filters.

The fact that the filters were impregnated with CO_2 leads to the statement of another item of interest, indirectly the result of using iron and lime. At times the water in the river reaches the plant with a turbidity of 5 or less, an alkalinity approaching 0, sometimes with a slight acidity, a CO_2 as high as 30 parts and magnesium, 17 to 24 parts. At such times the lime added to produce normal carbonates in the water to prevent the solution of the iron throws out the magnesium in sufficient quantity to act as a coagulant for the low turbidity and permits the supply of iron being cut out entirely.

Since beginning the use of iron and lime the quantity of hypochlorite of lime required to kill B. coli in the filtered water has been increased from 5 to 6 lb. to 8 to 10 lb. per million gallons. This is in accord with the theory that a longer time is necessary for a given quantity of hypo to act in a water free from CO_2 than in one with CO_2 present. In order to obtain negative results in testing for B. coli in the water leaving the plant, more hypo is required to complete the germicidal action with a water freed of CO_2 than formerly with CO_2 present, using alum.

Concrete Barges Stand Test

Two concrete barges or pontoons in service at Balboa on the Panama Canal recently passed through a successful service test, according to the *Panama Canal Record*. They were rectangular pontoons, 120 ft. long by 28 ft. wide by 8 ft. deep, with bottom, sides and deck of reinforced concrete. They were built to be used as landing stages for boats up to 65 ft. in length. The concrete in each is about 186 cu.yd. Buffer timbers were affixed at the ends and sides by means of anchor bolts.

At the time of the blowing up of the coffer-dam behind which the pontoons were built the surface of the water in the entrance basin was about 15 ft. below the mean tide level. The gap made by the explosion did not allow the water to pour in from the sea until the tide rose. The stream which broke over the dam at high tide cut an increasing channel in the earth, resulting in a strong inrushing current sufficient to make the barges part their moorings and circle about the basin. In so doing one of them struck a fender pile and broke it at a point about 20 ft. below the butt, where its diameter was about 12 in. The barge groaned under the impact, and one of the end timbers was sheared off, dragging its anchor bolts through the concrete and causing it to crack. This damage was above the water line. In other respects the pontoon was uninjured. The two pontoons collided once in their course around the basin, but this did no damage to either.

Both pontoons have been in regular use since that time as landings, and are standing the service well.

A 30-Mile Railway Tunnel Under the Cascade Mountains

By H. M. Chittenden*

SYNOPSIS—The longest railway tunnel ever projected is that proposed by the author of this article to carry railway traffic under the high mountain wall of the Cascades, which divides eastern and western Washington. The engineering problem as to whether such a tunnel would be a paying enterprise or not requires for its solution data on the cost of tunneling and shaft sinking and on the cost of railway-train movement on mountain lines and in tunnels. These data are given in the paper. General Chittenden was, when on the active line, one of the best-known officers of the Corps of Engineers. Through his service as Chairman of the Seattle Port Commission since his retirement from active service in the army, he has been brought in contact with traffic conditions in the Northwest. His project for the tunnel will receive the careful attention of the profession, not only because of its magnitude, but because at various other points in the United States, projects for long tunnels to carry railways under high mountain ranges are under consideration.

Puget Sound is one of the best terminals for ocean traffic in the world. On the Pacific Coast of the United States, where safe harbors are so few, Puget Sound is an asset of enormous value to the country's trade. But on its eastward side the Sound is hemmed in by the high mountain wall of the Cascades. The lowest passes across this great barrier are more than 3,000 ft. high, and in the more severe storms of the winter they become practically impassable.

In the past ten years there have been three winters in which rail traffic across the Cascade Mountains in Washington has been completely stopped for periods of from one to three weeks. There have been several other winters in which the interruptions, though less complete, have been serious. There have been only two or three winters in which approximately normal traffic conditions have been maintained throughout. During the past decade there have been some grave accidents with heavy loss of life, and there has been a prodigious financial loss to the railroads and the community. Last winter some of the worst storms on record visited the State of Washington, and the accidents, loss and inconvenience have again forced upon public attention the serious meaning of the Cascades problem. What this Cascades barrier means to the future development of Puget Sound and its usefulness as a seaport for the rest of the country may be estimated by imagining what such a barrier would have meant to the Port of New York, if Nature had planted a high mountain range entirely around that port from New Haven to Philadelphia.

Railroad enterprise has indeed done much toward overcoming this great handicap. Equal terminal rates place Puget Sound, in a certain sense, on a par with its great commercial rival, Portland, at the mouth of the Columbia, from which a water-grade route extends up the valley of the Columbia to the interior; but so long as the present high crossings are maintained, it will never be possible to eliminate the waste of energy involved in the half-mile vertical lift over the range; nor the delays, dangers and enormous maintenance cost due to heavy gradients, excessive curvature and to winter conditions.

A Tunnel Project

The problem as it presented itself to the writer ten years ago was: Can a route be found on which a tunnel may be built under the Cascades, at an elevation low enough to eliminate the worst grades and practically all the winter difficulties of the present crossings?

The destructive floods of November, 1906, first drew the writer's attention definitely to this subject, and in the course of the next two years he gave it a great deal of study. The Cascade Range had been thoroughly explored throughout its length, and the best passes had already been occupied. With the limited traffic of a new country, the railroads in their pioneer work could not afford long tunnels. The three so far built are, in the chronological order of construction: The Stampede tunnel (Northern Pacific), length 9,834 ft., elevation above sea level, 2,837 ft.; the Cascade tunnel (Great Northern), length 13,500 ft., elevation 3,375 ft.; and the Snoqualmie Pass tunnel

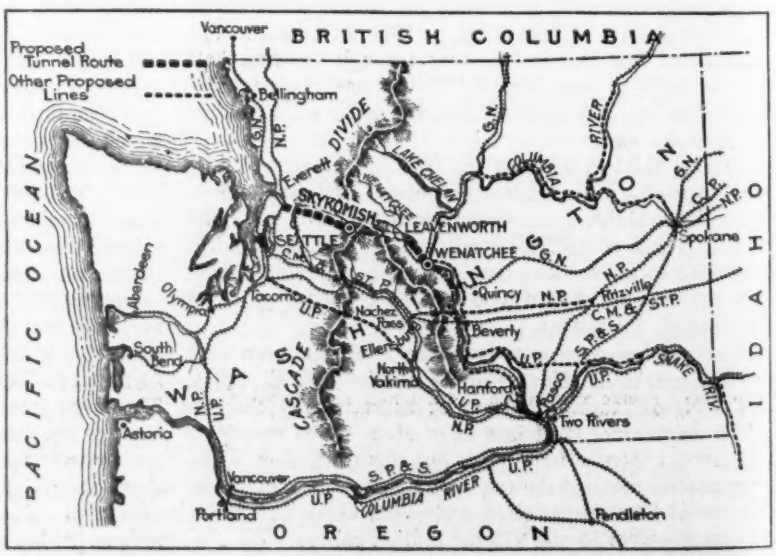


FIG. 1. SKETCH MAP, SHOWING THE RELATION OF PROJECTED TUNNEL ROUTE TO EXISTING RAILWAY LINES IN WASHINGTON

*Brigadier-General, U. S. A. (retired), 2010 Broadway, N., Seattle, Wash.

(Chicago, Milwaukee & St. Paul), length 11,890 ft., elevation, 2,560 ft. The gradients on the approaches to these tunnels range from 1% to 2.2% over distances varying from 10 to 30 mi.

As will be seen from these figures, the tunnels simply pierce the thin comb of the ridge, leaving the approaches for long distances supported upon precipitous mountain slopes with excessive gradients and subject to the dangers inseparable from such situations. It was manifest that no substantial relief from existing conditions was possible except by building much longer tunnels—three or four times as long at the very least; and it was equally manifest that the railways individually could not go to this expense unless driven to it by dire necessity.

This consideration suggested a combination by which the roads might jointly build a low-grade route between the Columbia River and the Sound. If such a route could be located where it would be conveniently available to the several lines, a large expense might be incurred without unduly burdening any single company.

The Most Feasible Route

Starting on this theory of a Puget Sound terminal railway, the writer carefully studied existing data for a possible location. It was a simple matter to demonstrate that there was but one such, but it was an unexpected satisfaction to find that this one would serve the through traffic of all the roads as well as, and some far better than, the present lines. This location is at the point where the Columbia River, in its great southern swing through the State of Washington on the eastern side of the Cascades, comes nearest Puget Sound—namely, at the mouth of the Wenatchee River. The distance between tidewater at Everett or Seattle and the Columbia at Wenatchee (elevation about 600 ft.) is barely 90 mi. The valleys of the Wenatchee (east side) and Skykomish (west side) are almost in direct line with each other and lead by possible gradients not exceeding 0.6% to points separated by a distance of only about 30 mi.

At no other point in the entire range could so favorable a situation be found that would be available to all the roads. The trend of the Columbia Valley from the Snake River to Wenatchee is westward and would lead the Northern Pacific and the Union Pacific to Puget Sound by as short or shorter routes than by their present lines. This may at first thought seem doubtful, but the map shows it to be true. It is interesting to notice how little this route from the mouth of the Snake to Everett on Puget Sound varies from a straight line. Table 1 and the accompanying profiles exhibit the distance and gradient relations of the proposed and existing routes.

First Presentation of the Project

Having demonstrated the very advantageous distance and grade relations of the new route and its availability for every Eastern line that now reaches Puget Sound or ever will, the writer proceeded to consider what to do with the 30-mi. obstacle which stood in the way of so desirable a consummation. It was at this point that he placed his professional reputation in jeopardy by suggesting that the whole distance be covered by a tunnel. The radical thoroughness of this solution of the problem, made possible by topographical conditions unparalleled in any other situation within the writer's knowledge, appealed to him very strongly. The project, once carried out, would be in every respect as advantageous as if the Columbia River itself had pierced the range at this point. Far to the south its course to the sea is through a defile nearly 200 mi. long. Here the short distance of 80 to 90 mi. would accomplish an even greater transition, for it would connect the interior with maritime facilities of the finest inland roadstead in the world.

The scheme was set forth by the writer in 1909 in a pamphlet, which considered the subject in all its phases. Its reception showed how local prejudice may prevent honest consideration of even the most important enterprises.

The Portland newspapers gave an elaborate review of the pamphlet, because it showed how dire were the straits in which Seattle admitted herself to be and from which she could never expect relief because, of course, the tunnel scheme was utterly visionary! The Seattle papers gave the project short shrift, dismissing it contemptuously and in hot anger that one of her citizens should *admit* that Puget Sound was laboring under any handicap com-

TABLE 1. TRAFFIC RELATIONS OF PROPOSED CASCADES TUNNEL ROUTE

Name of Railroad	Differences in Distance by Present and Proposed Routes Between Columbia River and Four Principal Ports on Puget Sound, Mi.* Tacoma	Seattle	Everett	Bellingham	Saving in Vertical Lift, Ft.	Location of Columbia Crossing
Northern Pacific (present route)	—45	—14	+39	+39	1,693	Pasco, just above Snake River
Northern Pacific†	+45	+76	+129	+129	1,693	Eight miles above Beverly
Union Pacific (via Portland)‡	+69	+136	+188	+188	No material difference	Two Rivers, just below Snake River
Chicago, Milwaukee & St. Paul§	—46	—28	+26	+26	2,255	Beverly
Great Northern‖	+48	+37	+23	+23	2,166	Wenatchee

*+ indicates saving by new route; — indicates loss. †Should the tunnel project ever become a reality, the Northern Pacific would extend its proposed Ellensburg cutoff (already begun) to the Columbia only and build thence to the new route at Wenatchee. The second group of distance relations in the table is figured on this assumption, and the initial point is taken at Ritzville, where the line leaves the present line of the Northern Pacific. Possibly a better route would be across the plain of the well-known Quincy Valley in a northwest direction, reaching the Columbia at about the same point that the Great Northern does, thus still further shortening the distance to Puget Sound. If that remarkable region—the Quincy Valley—is ever brought under irrigation, its enormous resources will produce a traffic that will be sought by all the railroads. ‡The distance relations of the Union Pacific have been figured from the mouth of Snake River, as the most central point of the activities of that system in the region round about. For traffic going southeast over the Blue Mountains, Pendleton would be the point to estimate from and the figures in the table should be reduced about 40 mi. The Union Pacific has also considered extending its Yakima Valley branch across Nachez Pass to Puget Sound. In that case the distance and gradient relations would be comparable to the first group in the table for the Northern Pacific, but even more favorable to the proposed tunnel route. §The Milwaukee crosses the Columbia about halfway between Pasco (where the Northern Pacific crosses) and Wenatchee, and the Northern Pacific, as already stated, has begun a parallel line a little north of the Milwaukee in order to shorten by something like 80 mi. its present roundabout route between Spokane and Seattle. Both these routes, immediately after crossing the Columbia, encounter natural obstacles second in magnitude only to those in the Cascades. The Saddle Mountain ridge lies between the Columbia and Ellensburg, involving very heavy work, gradients of 2% and a long tunnel. The Wenatchee line would save all this as well as the high Cascade crossings. The "North Bank" route from Pasco to Puget Sound via Vancouver, Wash., is closely comparable with the Union Pacific, so far as the data in the table are concerned. The Canadian Pacific has long sought an entrance into Seattle. It now operates into that city over the Northern Pacific from Sumas. It also operates into Spokane from Dunmore Junction. If it were to extend its Spokane connection to Wenatchee and utilize the tunnel route, it would save fully 125 mi. of distance and 4,700 ft. of vertical lift. This would be a great saving in freight, a matter of no little importance in connection with the grain export trade and shipments eastward of timber and fish products. Passenger traffic would make only a limited use of the line, because that is controlled largely by the scenic attractions of the Canadian Pacific *west* of Dunmore. ‖The distance figures for the Great Northern are based upon the assumption that a crosscut to Seattle will be built instead of going around by Everett, as at present, and that the Tacoma connection will be via the east shore of Lake Washington instead of through Seattle.

mercially as compared with Portland! In engineering and railroad circles the scheme was looked at askance, though there were many who referred to it as only a little in advance of its time and certain of ultimate realization.

The idea quickly dropped out of sight until the winter of 1910, when a disastrous tie-up occurred on all the lines and with it the appalling accident at Wellington on the Great Northern Ry. in which a passenger train was swept down the mountain side by an avalanche and most of the passengers killed. This brought the tunnel scheme into great prominence and general favor, and it was seriously proposed to take the matter to the state legislature. Upon the advice of the writer this was not done, as he considered such action at the time premature.

As always happens after great disasters, public interest in remedial measures waned rapidly with the lapse of time. The Great Northern, however, was faced with a situation that it had to meet at once, and this it proceeded to do by the erection of the most elaborate system of concrete snowsheds ever constructed. The cost has been very heavy.[1] No serious conditions arose thereafter until the past winter, when former experiences were gone through with, including even the avalanching of a passenger train on the Great Northern with serious loss of life, and a narrow escape from a similar accident on the Northern Pacific. It was reported in the press that the State Railway Commission had threatened to take a hand and compel the Great Northern Ry. to lower its tunnel.[2] The whole subject is thus revived again and every such revival serves to accentuate the necessity of definite action for the radical improvement of existing conditions.

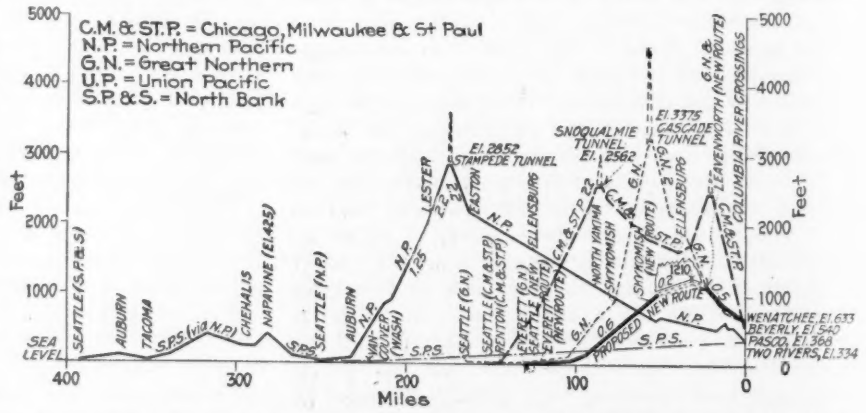


FIG. 2. PROFILES OF EXISTING RAILROAD LINES CROSSING THE CASCADE MOUNTAINS, AND OF PROPOSED 30-MI. TUNNEL LINE UNDER THE RANGE

With the foregoing general statement of the problem, let us examine in detail its technical and economic features. It may be stated at once that the technical problem presents nothing which should seriously challenge the resources of the engineering profession. The only feature that would establish a precedent would be the length, which would be nearly three times as great as that of any railway tunnel yet built.

The nearest approach is in the Alps, where there are five tunnels—Mont Cenis, 8 mi.; Saint Gothard, 9.3 mi.; Arlberg, 6.5 mi.; Simplon, 12.3 mi.; and Loetschberg, 9 mi.—the aggregate length of the three longer being just the same as that of the proposed Cascades tunnel. There are many railway tunnels in various parts of the world ranging from 2 to 7 mi. in length. The Catskill Aqueduct for the New York water-supply is 120 mi. in length, of which 49 mi. was driven in tunnel.

[1]The outlay by the Great Northern since 1910, including work now ordered, amounts to about $6,000,000 expended in snowsheds, tunnels and realignment. What the cost of accidents has been the writer does not know, but it must have been heavy.

[2]The chairman of the Public Service Commission has since informed the writer that the commission has compromised with the company on concrete snowsheds, their location and sufficiency to be approved by the commission's engineer.

Some of the Alpine tunnels developed obstacles much more serious than any which it is believed will be encountered here. The Cascades rock is mainly granite, with some schist at the western end and possibly a short stretch of sandstone about midway. (The geology along most of the line has not been developed, and these conclusions are based upon the geology along the Great Northern.) It is not likely that serious difficulty will be encountered from excessive heat, the sole surface indication being a warm spring on the Great Northern, 3 mi. north of the line and at elevation 2,200, with a temperature of 130° F. No trouble from this cause was experienced in any of the three tunnels already built through the Cascades. The Cascade granites carry more or less water, but not in troublesome quantities, judging from experience on the Great Northern tunnel.

If the tunnel were to be excavated only from the ends, a summit level about midway would facilitate drainage during construction. If shafts were to be used, this would not make much difference, unless one of the shafts were utilized to develop the water power of Icicle Creek. In that case the outflow would have to be to the east, because the irrigation districts of the east slope would not permit any of their water resources to be diverted to the west side, and the slope from the power shaft eastward would have to be sufficient to carry off the water. On the accompanying profile (Fig. 3) a summit is shown about 3 mi. west of the lower Icicle Creek shaft, with an elevation of 1,210 ft.

Rate of Progress and Cost

The cost of the work as affected by interest charges during construction is so dependent upon the rate of progress that both matters will be considered together in this division of the subject.

In the matter of progress in tunnel building there has been continuous improvement since the first long Alpine tunnel was built. This is well shown in the following table:

ALPINE TUNNELS

Name of Tunnel	Date	Length, Mi.	Rate of Progress, Ft. per Day
Mont Cenis	1857-71	7.5	7.75
St. Gothard	1872-81	9.5	18.00
Arlberg	1880-84	6.5	27.25
Simplon	1893-99	12.25	36.00
Loetschberg	1906-11	9.00	36.00

The Rogers Pass tunnel, now nearing completion, is a double-track tunnel nearly 5 mi. long through the Selkirk Range on the Canadian Pacific Ry. Progress has been

made at a rate of 3.6 mi. per year, or about 52 ft. per day. As an example of rapid work on a small tunnel (about 12 ft. wide and 13.5 ft. high), we may cite the Pirahy tunnel in Brazil, in which 27,657 ft. length was driven in 489 days, or 56 ft. per day. This work was done under great pressure for time and with the inducement of a liberal bonus. Several shafts were sunk to facilitate progress.[3]

Upon the whole, the Rogers Pass experience seems most applicable to our present estimates. The extraordinary record made was due to a favorable rock and to the use of the comparatively new method of driving a small auxiliary tunnel in advance of and at one side of the main bore, from which cross-galleries were run and additional headings opened up. Undoubtedly the same expedient would be applied to the much larger work here considered.

In the estimates for the Cascades tunnel the following dimensions for the cross-section of the tunnel have been assumed: Width, 30 ft.; height at center, 25.5 ft.; height over outer rail, 22.5 ft.; net cross-sectional area (after lining), about 650 sq.ft.; gross area in excavation, about 850 sq.ft.

Sinking Intermediate Shafts

The great length of the tunnel naturally suggests resort to intermediate shafts in order to facilitate progress. The question of their use turns mainly upon their effect in shortening time of completion and thereby saving interest and hastening the period when the work may become revenue producing. These shafts would be expensive, about $100 per foot depth for a deep shaft of, say, four compartments (about 250 sq.ft. cross-section) and would take considerable time to construct, 100 ft. per month being standard experience.[4] Four possible locations are indicated on the profile (Fig. 3). In analyzing their probable value in expediting the work and reducing interest charges a somewhat higher rate of cost than previously indicated has been assumed—namely, for the lower Icicle Creek shaft (1,100 ft. deep), $150,000; for the Middle Icicle and Deception Creek shafts (1,700 and 1,860 ft. respectively), $250,000; and the upper Icicle shaft (2,320 ft.), $350,000. The estimated effect of these shafts in reducing time and cost is shown in Table 2.

Ventilation and Water-Power Development

The pioneer tunnel and the several shafts would be of great value in the subsequent operation of the tunnel. While ventilation with electric-train operation is not a difficult problem, still it would be materially simplified by the auxiliary tunnel and the shafts. High-speed operation of trains would be essential, and the air pressures would be lessened by frequent connections with the side tunnel, while the shafts would have a similar effect and would promote frequent complete changes of air.

Two of the construction shafts could be cheaply utilized for the development of power. Icicle Creek has a dependable low-water flow at the site of the lower shaft of over 50 sec.-ft. The head at the shaft exceeds 1,000 ft. Corresponding data for Deception Creek are 20 and 1,850. In addition to these shafts, designed primarily for construction purposes, a small one for power only could be let down from the Wenatchee River. The head would be a little over 200 ft., and the dependable low-water flow in excess of 500 sec.-ft. These figures indicate a possible aggregate development of 21,300 hp. theoretical. The water would be disposed of through the auxiliary tunnel and would require but a small percentage of its space, except from the Wenatchee shaft outward, where it would require practically all. With any reasonable assumption as to volume of traffic, this power ought to operate the entire line from Wenatchee to near Monroe, with sufficient surplus to ventilate and light the tunnel. That is to say, the tunnel itself, by the mere fact of its construction, would create power not otherwise available sufficient to operate the entire terminal system here considered.

Computing Rate of Progress

At Rogers Pass, as already stated, a rate of progress of 3.6 mi. a year was attained, or a mean of 1.8 mi. from each end. In the estimates from which Table 2 is made up, it is assumed that 1.6 mi. per year could be maintained from each portal and 1.4 mi. each way from each shaft. It is assumed that the widening for necessary sidetracks would be equivalent to 1.2 mi. of full tunnel section, thus making an equivalent total length of 32 mi. If shafts were used, the time would be controlled by the longest subdivision and by the rates of progress at its two ends. Thus, with no shaft, the length would be 32 mi. and the annual rate 3.2 mi.; with one shaft, the controlling section would be 17.4 mi. and the rate 3 mi.; with two shafts, these figures would be 14.4 and 3 respectively; with three shafts, 11.2 and 2.8; and with four shafts, 7.5 and 3. It is assumed that two full years would be consumed in installation of plant, including shafts, and in getting well started; 12 months in getting the tunnel into operation after the main bore is holed through. The times of completion under these assumptions are shown in Table 2.

In arriving at an estimate of cost the writer has relied largely on the Rogers Pass experience, but has consulted other work and authorities as well. He believes that the following unit prices are conservative, if the tunnel is driven from the ends only:

	Per Lin.Ft.
Plant (except shafts)	$5
Excavation of bore	120
Lining tunnel	75
Tracks and equipment	5
Surveys and miscellaneous	5
Total	$210

It is assumed that the item for excavation from the shaft headings will be $5 greater than given in the preceding tabulation, this increase to cover the extra cost of removing muck and water through the shafts.

[3] "Engineering News," May 18, 1916, p. 921.

[4] The Woodbury shaft now being sunk in the Lake Superior mining region has already reached a depth practically the same as that of the deepest shaft here proposed. The rock is quartzite and granite. There is but little water. The net dimensions in cross-section are 13 ft. 1 in. by 21 ft. 1 in. The gross dimensions in excavation are about 15x23 ft. The shaft was sunk 2,180 ft. in the period from Mar. 1, 1915, to Mar. 1, 1916, or at an average monthly rate of 182 ft. The average cost, including everything complete, has been $102.30 per lin.ft. The shafts herein proposed would not be quite so large as the Woodbury shaft and would probably cost no more per unit of depth. Our estimate, both as to time and cost, would therefore seem to have a margin of safety of 50%. The cost of shaft operation in the Lake Superior region is about 8c. per ton of material hoisted. Assuming a figure of 10c. in the case here considered, headings of 850 sq.ft. and a weight of rock of 170 lb. per cu.ft., the cost of the hoisting would be about $7.20 per lin.ft. of tunnel. Offsetting this by the cost of removal of the material by way of the portals, if the tunnel were excavated without shafts, the additional cost by the use of shafts, assumed in this article as $5 per lin.ft., would seem to be about right.

With the foregoing assumptions, with an interest rate of 6% and an interest period equal to half the period of construction, the details as to costs and times are shown in Table 2. The second column includes the increased plant cost of shaft installation as already given and the extra cost of $5 per ft. for removing muck and water by the shafts.

TABLE 2. TIME REQUIRED FOR COMPLETION AND COST OF CASCADES TUNNEL

Scheme	Cost	Time, Yr.	Interest	Total
No shafts	$35,481,000	13.0	$13,837,000	$49,318,000
One shaft	36,127,000	9.0	9,754,000	45,881,000
Two shafts	36,429,000	8.0	8,743,000	45,172,000
Three shafts	36,659,000	7.0	7,698,000	44,357,000
Four shafts	37,114,000	5.5	6,123,000	43,237,000

A. C. Dennis, Superintendent for the contractors on the Rogers Pass tunnel, to whom the writer referred these estimates, expresses some doubt as to the practicability of securing this efficiency from the shafts. He is inclined to favor doing the whole work from the portals only, or at least using only the one shaft nearest midway of the tunnel. In this connection he made the following observation in a letter to the writer:

Under normal rock and water conditions this tunnel can be finished ready for operation, working from the portals only, in nine years. With a bonus, or forfeit claim based on nine years' time limit, I am satisfied that this work can be let for $33,000,000, to cover every expense in connection with the work until ready for operation and with an additional reduction of $70 per ft. for any unconcreted section.

The costs as given in Table 2 pertain to the tunnel only. To make this work properly available by giving unrestricted access to all railway lines, the system should be extended on both sides to the natural points of divergence, say to Wenatchee on the east side and to some point near Monroe on the west. This would add probably 50 mi. of open-country double track, which we will estimate at $4,000,000. A more complete system would result if it were extended into Everett, Seattle and along the east shore of Lake Washington to Renton, from which point all lines are available to Tacoma. Doubtless this would be the ultimate outcome.

It may be objected that this route would be practically available to only one of the railroads entering the Puget Sound country—namely, the Great Northern, which lies directly on the route of the tunnel. The answer is that, long before such a work could be carried to completion, the development of the Columbia Valley will have brought the other lines as far north as Wenatchee for local traffic only.

The Economic Problem

We come finally to the crucial test that any project of this character must pass before it can commend itself to the favorable judgment of practical men. As an economic proposition, will it pay? To answer this question as we should like to answer it would require definite data concerning the traffic movements across the Cascade Range and the saving on that portion which could advantageously use the new route; the saving in future maintenance and construction cost to the several lines affected; the saving to the railways by avoidance of delays, interruption of traffic and losses from accident; and finally the advantage to the public in different ways.

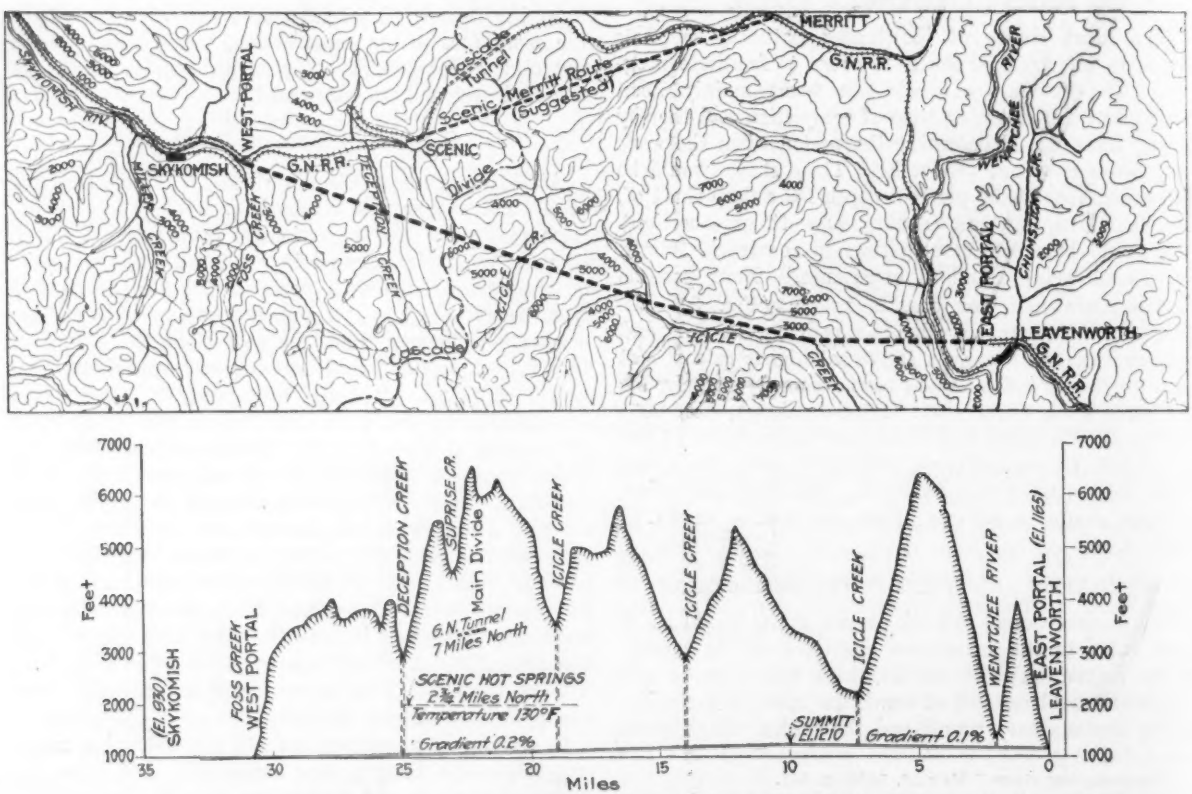


FIG. 3. MAP AND PROFILE OF PROPOSED 30-MI. RAILWAY TUNNEL AND APPROACHES UNDER THE CASCADE MOUNTAINS

It is manifest that a complete analysis of the problem on this comprehensive basis is a practical impossibility. The records of the railroads are not kept in form to furnish the precise information necessary. The cost of freight movement is so intimately dependent upon its

volume that conclusions based upon a particular example might be quite inapplicable to any other. Then, the effect upon the public interest is never made a matter of record—in fact, could not be—and therefore the public advantage of the new route, though certainly very great, cannot be computed in definite terms.

The best we can do as to the several railroads is to show for each the difference of conditions between present service and that by the proposed route, and then make the best assumptions we can as to the saving due to this difference. It is manifest that the advantage to some would be greater than to others, even for the same volume of traffic, and that mere tonnage figures would not be a sufficient guide. With frank acknowledgment of the unavoidable uncertainties, both as to the data and assumptions involved, we will state the conclusions reached.

Great Northern—The other railways would still maintain their present lines for local traffic and possibly to some extent for through traffic, but the Great Northern would probably abandon most of its present line between Skykomish and Leavenworth, these points being at the foot of the mountain grades on the two sides and the locations of the portals of the proposed tunnel. This would mean abandoning 57 mi. of railway, all of which requires pusher service and has gradients as high as 2.2%, curvature amounting to 6,855°, an average vertical lift of 2,335 ft., mountain grades costly to maintain and dangerous to operate, enormous winter difficulties, 3 hr. passenger time and 10 hr. freight time. In its place the company would have a nearly straight and level line, free of all the difficulties just enumerated, with a passenger time of 40 min. and a freight time of 1.5 hr.

The writer has obtained four separate and independent estimates of the probable annual saving by the proposed route on the basis of four passenger trains and six freight trains each way daily. One of these estimates is based upon Wellington's treatise, another upon an analysis of the Rogers Pass tunnel problem, a third is by a prominent railway engineer, and the fourth is independently worked out by the writer. These estimates range from about $900,000 to $1,500,000 on the basis of present service. Capitalized at 7%,[5] this would indicate a justifiable expenditure of from $13,000,000 to $20,000,000 to produce the proposed change.[6]

The higher figure may be reached in a different way. The late Alexander Stuart, the Great Northern's engineer on this coast for many years, strongly urged the building of a new tunnel between Scenic and Merritt (see Fig. 3), a distance of about 13 mi., reducing the vertical lift about 1,200 ft. and the distance about 11 mi. The project, indeed, was about halfway in magnitude between the present Great Northern tunnel and that proposed by the writer. The cost would probably have been about $15,000,000. There is little doubt that the Great Northern might better have followed this advice than the course it has pursued, which has already cost a sum fully half as great as that of the Scenic-Merritt route without any of its advantages. But the point here emphasized is that, if this tunnel would have been a justifiable project at the cost stated, the larger tunnel would certainly justify an outlay of $20,000,000.

Northern Pacific—The advantage of the proposed route to the Northern Pacific must be estimated from the second group of traffic relations given in Table 1, based on the construction of a line west from Ritzville to the Columbia River. The cost of the proposed line from the Columbia to Ellensburg (the Ellensburg cut-off, which would become unnecessary if the tunnel project were adopted) would easily build the line up the Columbia to Wenatchee.

The average distance by the existing line between Ritzville and Puget Sound points (324 mi.) would be reduced about 90 mi. and the vertical lift about 1,850 ft. Assuming that the train-mile cost over the mountains, with extensive pusher service, will average $2.25, and by the proposed route $2, and that the through traffic which would take advantage of this route would amount to eight trains a day each way, we should have an indicated annual saving in train service of $1,242,840, which would justify an outlay of $16,000,000. The time is rapidly approaching, moreover, when the Northern Pacific will have to double-track its line across the Cascades, and it may very likely be necessary to lower its present tunnel. Such a course would involve a cost of probably $10,000,000, which might far better be applied to the more thorough project here proposed.

Union Pacific—Second only in its advantages to the Great Northern, and possibly even exceeding them, would be those of the proposed tunnel route to the Union Pacific.

The project which the Union Pacific at one time had in mind of building down the Snake River from Huntington, thus flanking the Blue Mountain Range, was found not to be worth while, so far as its present line down the Columbia is concerned, because the increased distance and curvature more than offset the climb over the mountains. But such a project would fit in perfectly with the proposed tunnel route and would give a low-grade line from Puget Sound all the way to the Wyoming plateau and the mountains of Colorado.

The average saving of distance between Puget Sound and Inland Empire points by the proposed route as compared with the detour via Portland would be at least

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[5]Rates of 6% for corporate funds and 5% for funds guaranteed by the public (state, counties or cities) are generally held to be amply sufficient. This would increase the capitalization figures here given by 14 to 20%.

[6]Since the above estimates were prepared, the writer has obtained the train-mile costs on two widely dissimilar divisions of the Great Northern Ry. One of these is the Cascade division, extending from Leavenworth to Seattle, and includes the mountain section between Leavenworth and Skykomish. The other is a prairie division in North Dakota, on which both gradients and curvature are very light, being comparable in these respects to the proposed tunnel section here considered. The train-mile costs are averages for the entire division in each case and include all expenses of operation, etc. They apparently do not include the item of snowshed construction. The average totals on the two divisions are per train-mile: For freight service, $5.40 on the mountain division and $1.90 on the prairie division; for passenger service, $1.72 on the mountain division and $1.05 on the prairie division. Applying these figures as they stand to the Skykomish-Leavenworth section, with the same assumptions as before as to the volume of traffic, we have an indicated annual saving of $1,447,250, virtually the same as the largest of our previous estimates. But this, manifestly, does not tell the whole story. The train-mile cost on the Skykomish-Leavenworth section may be assumed conservatively as 50% greater than upon the Cascade division as a whole. On the other hand, the train-mile cost on the tunnel section, if the tunnel is built with the thoroughness that it naturally would be, would probably be less than that on the prairie division above given. Be this as it may, the cost itself would be divided among the coöperating roads, which amounts to saying that it would be distributed over a traffic three or four times as great as that on the main line of the Great Northern. This would reduce the train-mile cost by one-third at the very least. Revising our estimate on the basis of 50% increase of cost over the figures for the mountain division and one-third decrease from the figures for the prairie division, we have an indicated annual saving of over $2,100,000. These figures show that the Great Northern can pretty nearly afford to build the tunnel single-handed, if funds can be raised at 6%, if snowshed cost be taken into consideration and if reasonable allowance be made for increase of traffic by the time the tunnel is completed.

180 mi., while that via Pendleton to southern Idaho, Utah and the southeast would be about 140 mi. Assume an average of 160 mi., a traffic of eight trains daily each way, a train-mile cost of $2 by either route, and we have an indicated annual saving of about $1,870,000. Deducting a reasonable sum for building connections on the two sides and for a proper share in the maintenance of the new route, we shall still be justified in claiming a net saving of $1,400,000, which should justify an outlay for construction of $20,000,000.

Considering now the proposed Nachez Pass extension, the average distance to Puget Sound points from, say, the mouth of Snake River may be taken as the same as that by the Northern Pacific from Pasco—about 250 mi.—which is approximately the same as by the proposed tunnel route. The construction of this extension, with an adequate tunnel at the summit, would cost probably $15,000,000, and the route would then be subject to all the drawbacks of these high crossings. Assuming an operative cost over the range 25c. greater per train-mile than by the low tunnel route and a traffic of eight trains daily each way, we have an indicated annual saving of $365,000, which would justify a capital expenditure of $5,200,000. Adding this to the construction cost of the Nachez Pass route, we have practically the same result already arrived at.

FIG. 4. A TYPICAL VIEW IN THE CASCADE MOUNTAINS

Chicago, Milwaukee & St. Paul — The Milwaukee system would profit least of any by the proposed route, as compared with its present line, because the distance from the Columbia to Puget Sound points would be lengthened about 25 mi. Assuming the present average distance to be 170 mi. and, owing to the two summits, the heavy gradients and excessive curvature, the train-mile cost to be $2.50 as compared with $2 by the tunnel route, we have for an eight-train daily service each way an indicated annual saving of $205,000, which would justify an outlay of about $3,000,000. The time will come, it must be assumed, when increase of business will make it necessary to double-track its present line between the Columbia and the Sound. The cost of such an enlargement, with its two mountain crossings and two long tunnels, might far better be expended in aid of the proposed low-grade route.

From the foregoing analysis it is apparent that, unless we are utterly astray in our assumptions, the four transcontinental lines having access to Puget Sound could well afford, as an economic proposition, to build this low-grade route between the Sound and the Columbia River. The tonnage between Puget Sound and points east of the Cascades, including the small percentage that moves by the Canadian Pacific, the Union Pacific and the "North Bank" (Spokane, Portland & Seattle Ry.), is over 60,000 tons daily. This is train tonnage and includes passenger as well as freight traffic and also locomotives. It represents the average total load daily hauled in and out of the Puget Sound country, fully 90% of which could advantageously use the proposed route, if developed on the lines herein suggested. If we assume, as was done in the preliminary studies of the Rogers Pass project, a doubling of traffic by the time the work is completed, the justification of the expenditure would be overwhelming.

Difficulties in the Way

What, then, are the chief obstacles in the way of so important a consummation? We have shown that they are neither technical nor economic. Carried out as proposed, the project would be practicable from an engineering point of view and feasible from an economic point of view. The real obstacles are of a character far less definite, but also far more troublesome to deal with.

There is, first, the heavy investment in existing lines. The most striking example is that of the "North Bank" line (a Great Northern-Northern Pacific property) between Spokane and Portland along the Columbia River. It is one of the best-built railways in existence and is said to have cost upward of $40,000,000. It is idle now to argue that this immense sum, or a part of it, might better have been spent in securing an equally good route through the Cascades to Puget Sound. The "North Bank" is a fact, and it must get a great deal of business in order to pay its fixed charges and running expenses, to say nothing of paying dividends. Anything that might cut into this business as the proposed tunnel route would certainly do, would naturally be looked upon with disfavor from this particular direction.

Another intangible obstacle in the way of this comprehensive course lies in the independent action of the several roads. Each will continue to improve its present lines by building snowsheds, making minor changes of alignment, etc.; and the more each expends, the less will it be inclined to aid in the greater work.

Then there is the perfectly natural opposition to permitting the invasion by one railroad of territory heretofore exclusively tributary to another. It is too much to expect of railroad human nature that the Great Northern, for example, would welcome with open arms any other line within its exclusive bailiwick of the Wenatchee and Upper Columbia Valleys.

Finally, there is the "get-together" difficulty—the proverbial reluctance to direct coöperation on an extensive scale among independent and competing lines. Fortunately, the State of Washington furnishes a complete answer to this objection in several of the most enlightening examples of coöperation to be found anywhere. The Great Northern and Northern Pacific jointly built the "North Bank" road. The Union Pacific, instead of building a separate line from Portland to Seattle, secured traffic privileges over the Northern Pacific from Portland to Tacoma and over the Milwaukee from Tacoma to Seattle; later, the Great Northern secured similar privileges over the Northern Pacific, covering the whole distance. As a part of this agreement the Northern Pacific has double-tracked its entire line from Portland to Seattle. All these examples show that coöperation among railroads, even where there is strong competition, is no new thing in this section of the country.

It is apparent from the foregoing that the real obstacles in the way of this project are of that indefinite and intangible character that only mature study and consideration can overcome. They are based upon prejudices rather than upon facts. The purpose that the writer has chiefly in view in this presentation of the subject is to turn public thought in this direction and dissuade the railways from continuing the policy of radical improvement of their present lines in the Cascades until they have thoroughly investigated the advantages that would result from building this 30-mi. tunnel.

Public Aid

A work of this magnitude, fraught with so many public benefits, is entitled to public aid. Commerce, both intra- and interstate, is frequently brought to a standstill under present conditions, mails are interrupted, vexatious delays are experienced, and business is temporarily demoralized. These are evils of a public character which justify public action for their removal. It is idle, however, to expect any aid from the Federal Government. Although the project would accomplish more for the benefit of interstate commerce than the improvement of the Columbia River,[7] for example, and although it would facilitate traffic where the interests of the Government are particularly heavy, still it would be practically impossible to induce Congress to grant any assistance. The precedent would be too far-reaching.

But with the State of Washington the project would be a measure of internal development of the first importance. On one side of the great mountain wall that stretches from north to south across the state is a great and richly favored maritime section, abounding in the finest harbors in the world. On the other side is a rich agricultural domain, which has come to be called, not inappropriately, the Inland Empire. The wall that separates these two sections compels trains to climb half a mile into the air to get over it and entirely stops all highway communication for six months in the year. The state can well afford to make a considerable investment in order to bring these two sections into closer relations with each other.

All that New York Harbor has meant to the State of New York, Puget Sound should mean to the State of Washington; and all that the Erie Canal meant to the states bordering on the Great Lakes, this low-grade route should mean to the Northwest. When New York had a population of about a million, it assumed the burden of building the Erie Canal and paid for it $7,600,000. If the State of Washington were to make the same per capita contribution to this work, based on its probable population when it is done, it would amount to more than $10,000,000.

It would be easy to demonstrate, if space permitted, that this tunnel could be utilized, in addition to its ordinary rail service, to maintain highway traffic between the sections for the year round. Such traffic is now

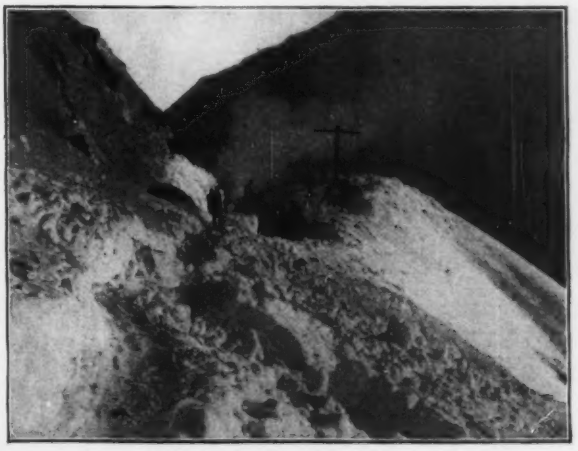

FIG. 5. A SNOW BLOCKADE IN THE CASCADES

wholly non-existent for seven months of the year, and of little practical value the rest of the time. This is one specific example of justification of public aid which certainly does not fall within the constitutional provisions which exist in the State of Washington against lending the credit of the state to private individuals, companies or corporations.

None of this public aid should be given outright, but it should be made available, say, when the main tunnel is first opened, with a definite time limit fixed within which the work must be done. This would obviate risk of failure and avoid interest charges until the work is ready for use. If such a sum could be guaranteed, subject to these conditions, it might prove of great assistance in encouraging an early undertaking of the work.

[7] The Government outlay on the improvement of the Columbia River above Portland aggregates $11,000,000, or nearly one-third the cost of the proposed tunnel. Yet it is doubtful if the river will ever carry 10% of the traffic that would pass through the tunnel.

A Landslide on the Great Northern Ry. in the Cascade Mountains occurred on Sept. 13, after the preceding article was written. It is remarkable because of its occurrence at the driest season of the year. The Seattle "Post-Intelligencer" of Sept. 14 said:

Passenger trains of the Great Northern Railway Co. were routed over the Northern Pacific lines last night following a big slide of earth, trees and débris at Windy Point. The slide covered the entire track for 400 ft. and is about the same point where a fatal slide occurred last year.

Pneumatic Mixer Lines Railway Tunnel Under Traffic

SYNOPSIS—Sandy Ridge tunnel on Carolina, Clinchfield & Ohio Ry. is being lined under traffic with concrete mixed and delivered from gasoline-driven car equipped with pneumatic mixer. Steel forms in 30-ft. sections are moved from place to place in tunnel. Records of progress.

The Sandy Ridge tunnel on the Elkhorn extension of the Carolina, Clinchfield & Ohio Ry., which was opened for traffic in 1915, is being lined with concrete, the pneumatic process of concreting being used, with the novel addition of a portable mixing and placing plant. The system comprises the following elements: A self-propelled mixer car, a loading and storage trestle, a compressed-air plant outside the tunnel, an air pipe line through the tunnel, and forms that can be easily erected, moved and taken down. The tunnel is 7,804 ft. long by 19 ft. wide.

The central element of the method is the concreting car, shown in Figs. 1 and 2. This is a steel frame, gasoline motor-driven car, carrying a pneumatic concrete mixer and space for aggregate, cement and water. It is run into the tunnel on the regular railway tracks and mixes and delivers the concrete through the medium of air compressed outside the tunnel and delivered through a pipe line with regularly spaced taps, to which the mixer on the car is attached.

The dimensions of the car are 40 ft. long over end sills, 10 ft. 4½ in. wide over braces, and 17 ft. 9 in. from top of rail to top of car. A central chamber, open on the sides, 8½ ft. long, 9 ft. 8 in. wide, and 10 ft. 3 in. high, contains on one side the pneumatic concrete mixer and on the other side the charging skip. Over this chamber is a water tank of 1,850 gal. capacity. This furnishes water for the concrete and is also connected with the cooling system for the gasoline engine. Facing the central chamber is the stone bin (30 cu.yd. capacity) on one end and the sand bin (12 cu.yd. capacity) on the other. Each bin has a chute 20 in. wide leading to the charging skip, and each chute is controlled by an undercut gate. Under the stone bin is space occupied by a 96-cu.ft. air receiver standing vertically and also space for storage of bags of cement, which is protected from water by the bin overhead.

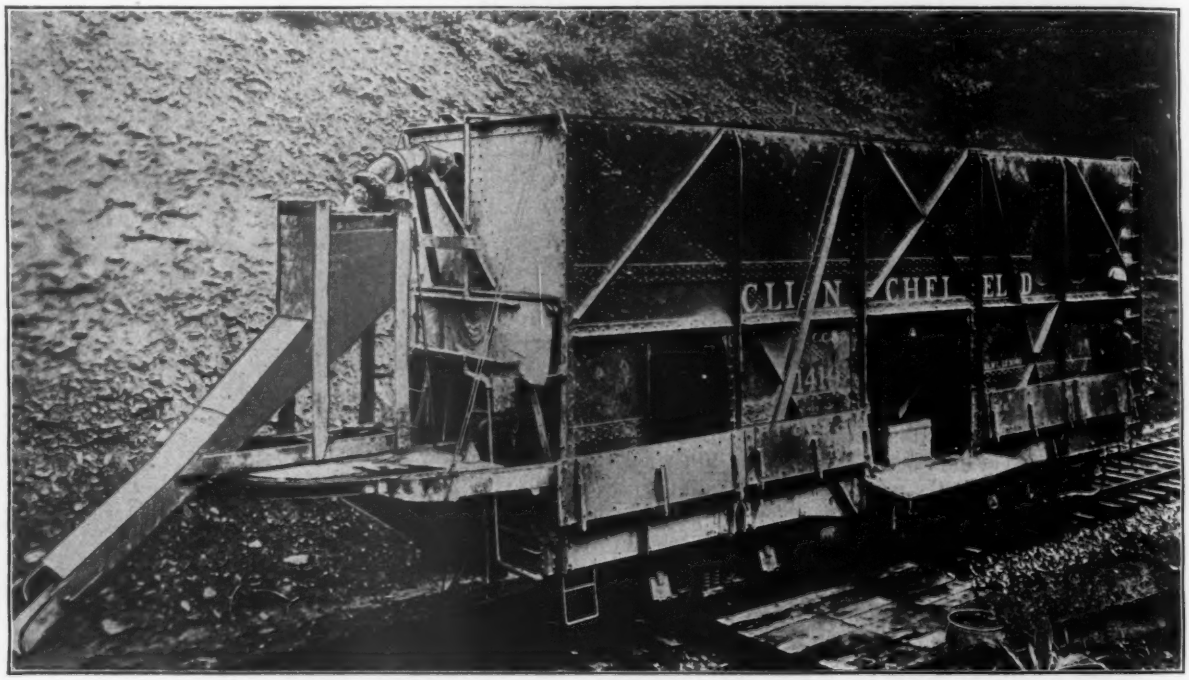

FIG. 1. CONCRETING CAR FOR CAROLINA, CLINCHFIELD & OHIO RY. TUNNEL
Delivery pipe arranged for sidewall concreting

LINEAL FEET OF CONCRETE PLACED AND HOURS OF LABOR IN LINING SANDY RIDGE TUNNEL

	Lineal Feet of Concrete Placed						Number of Hours Spent on Each Operation							
1916 Month	Form 1	Form 2	Form 3	Form 4	Form 5	Total Lin.Ft.	Building Masonry	Moving and Setting Forms	Trimming Sidewalls and Roof	Unloading Material	Night Watchman	Repairs to Plant	Miscellaneous Work	Total Hours Worked	Remarks
February	112	112	112	112	140	588	4,606	1,110	1,769	818	372	137	273	9,085	
March	83	112	112	112	84	503	3,644	2,410	1,279	980	348	384	384	9,393	
April	140	112	112	112	140	616	4,280	2,779	1,447	860	372	295	...	10,013	
May	112	140	140	140	140	672	4,169	2,587	1,324	905	372	93	448	9,898	
June	140	112	112	112	140	616	3,455	1,366	1,312	797	372	90	590	7,982	
July	28	28	56	56	28	196	1,370	1,018	802	560	372	132	140	4,456	15 days repairing flood damage
August	28	...	...	...	28	56	646	440	160	210	366	100	484	2,400	24 days repairing flood damage
Sept. 1 to 20	28	28	28	56	...	140	1,465	910	200	280	240	50	2,252	5,397	Delayed 60 hr., no cement

Under the sand bin is the gasoline engine and its auxiliary equipment, completely housed from water and dust. In its lower position the charging skip stands with its top rim about 1 ft. 3 in. above the floor, and it travels on inclined guide-rails (40-lb. T-rails) to its upper position over the mixer, being hoisted by a compressed-air cylinder 9¼ in. diameter. The gate of the skip works automatically by means of a guide-rail. The mixer is for a two-bag batch ($\frac{4}{10}$ cu.yd.) and has its 8-in. outlet pipe at the bottom running horizontally and curving to the outside of the rear truck and thence vertically to near the top of the car, where it branches by means of a Y into two lines—one a 180° bend to the rear for "shooting" in foundation and sidewall, and the other going to the roof for "shooting" into the arch.

The entire arrangement is made compact with a view to saving manual labor. One man controls the hoisting of skip, injection of water and mixing and discharge of the batch. One man is placed at each chute, and two men carry, open and empty the cement bags. The car and gasoline engine were built by the McKeen Motor Car Co., of Omaha, Neb. The car was sent knocked down and was erected in the railway shops at Erwin, Tenn., and moved to the work (105 mi.) under its own power, traveling at speeds of as high as 25 mi. per hr. The mixer was installed and the piping done on the car by the Pneumatic Placing Co., of 2 Rector St., New York City.

FIG. 2. CAR AT ENTRANCE TO SANDY RIDGE TUNNEL
Delivery pipe arranged for arch concreting

Loading and Storage Trestle

The service trestle is of special design and is so arranged that the concreting car goes under it and receives stone (crusher run), sand, cement (in bags) and water, all by gravity and frequently all at the same time. The sand and stone are drawn from overhead bins by means of undercut gates. Cement is conveyed into the car by a chute. The trestle (Fig. 3), has over its deck a track upon which stone and sand in hopper cars are stored or unloaded into the bins below. There is a continuous row of 27 bins with an aggregate capacity of 324 cu.yd. and a total length of 162 ft., and five loaded cars can be stored over these bins, giving an additional storage of 200 cu.yd. The trestle is built of timber and has a somewhat unusual arrangement of posts and bracing.

FIG. 3. LOADING TRESTLE FROM SOUTH PORTAL OF SANDY RIDGE TUNNEL

The forms are of steel, except the arch ring, which is of 3-in. hard pine on steel ribs. They are of the Blaw collapsible type and are held to the rock wall by anchor bolts, as shown in the sketch (Fig. 5). First, a hole is drilled in the rock, and a rod 18 to 20 in. long, split at one end and threaded at the other, is inserted, with the point of a wedge just entering the split. The rod is driven against the end of the hole, causing the wedge to spread the split end. A square cast coupling or nut is screwed on the tapped end of the rod, and a second rod is screwed into the outer end of the coupling. A similar coupling is placed on the free end of this second rod, and the last section of the hanger is screwed into this coupling.

The most important feature of the hanger is the square couplings, whose shape prevents their turning in the con-

FIG. 4. A 30-FT. SECTION OF STEEL FORMS

crete when the outer rod is unscrewed. Pipe couplings were tried at first, but being round, they turned with the rod and gave much trouble. Standard bolt thread is used as being more satisfactory than standard pipe thread.

Five 30-ft. sections of forms are provided, and these are distributed through the tunnel as seems best. On account of the pressure of the wet concrete an entire section is not concreted in one operation. After concreting the walls up to spring-line the car moves to another section.

Had it been possible to place concrete at full capacity, the five sections would probably have proved inadequate to keep the car busy. Difficulty in obtaining sufficient cement—due to some local conditions—has kept the rate of progress notably low.

Sand-Bag Bulkhead Retains Concrete

When a section is moved to a new position, one end is caused to overlap the concrete last placed. At the other end of the form a bulkhead of sand bags is constructed. Burlap bags are preferable, but cement bags also can be used. These are half filled with sand and

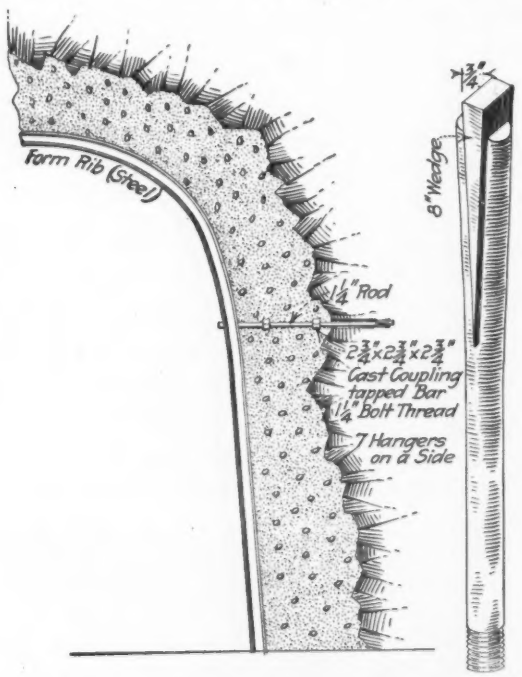

FIG. 5. HOW THE STEEL FORMS ARE HELD IN PLACE

are stacked a foot thick all around the opening, the bulkhead rising with the concreting.

The progress in lining, from February to September inclusive, is given in the table on p. 936. The sharp drop in "concrete placed" in July, August and September is attributable to lack of cement.

The concreting car was put in service on July 9, 1915. The high record for concrete placed in one day was 230 cu.yd., on May 12, 1916. The daily records and monthly totals for the summer months just past were respectively as follows: June, 214 yd., total of 4,098; July, 191, total of 1,570; August, 154, total of 508; to Sept. 20, 184, total of 1,347.

The maximum advance was made in May, 1916, the weekly totals being as follows: First week, 590 cu.yd.; second, 1,020 cu.yd.; third, 1,098 cu.yd.; fourth, 990 cu yd.; fifth, 564 cu.yd. The total concrete placed from July 1, 1915, to Oct. 31, 1915, was 10,438 cu.yd., while from the latter date to Apr. 30, 1916, the weekly totals averaged more than 600 cu.yd. It is expected that the tunnel lining will be finished next summer.

The work is being done by the company forces under the general direction of O. K. Morgan, Engineer in Charge of the railway, who also designed the car.

The Motor-Truck Menace to Street Pavements

A paper by Eugene W. Stern, chief engineer of the Bureau of Highways, Borough of Manhattan, New York City, on the "Necessity for Limiting the Loads, Speed and Size of Vehicles," read before the American Society of Municipal Improvements at Newark, N. J., Oct. 12, gives in greater detail than the article in *Engineering News* of the same date, the damage done New York City pavements by the 18- or 19-ton motor trucks used to haul material from the subway excavations. The pavements ruined include not only the granite-block pavement on West 42d St., but the sheet-asphalt pavements on this and West 50th St.

All this damage, Mr. Stern said, has been done in a very short time (about nine months) and has amounted to 5,400 sq.yd. of repairs on granite blocks (equal to 32% of the total area), costing $6,000, and 1,900 sq.yd. of repairs on sheet asphalt (equal to 30% of the total area), costing $1,900, whereas prior to this time the average cost per year of maintenance on these granite-block pavements was $150 and on the sheet asphalt $70.

In common with others who have studied the problem Mr. Stern comes to the conclusion that little damage is to be anticipated from vehicles with rubber tires, because as he said, "The manufacturers of motor vehicles have found by experience that about 750 lb. per in. width of tire is about all the load rubber tires will stand, and this load, together with the resiliency of the rubber and the adequate springs that good construction demands, seem to be the saving features in protecting the pavements against undue wear, even under heavy loads."

Mr. Stern contended that immediate action must be taken to protect not only the pavements of the cities and the municipalities immediately surrounding the cities, but also the country highways that are liable to be exposed to such kinds of traffic, as the taxpayers will be called upon to make very heavy payments to maintain their streets and highways, although these have been constructed in thoroughly first-class manner and in accordance with the latest practice.

An investigation was made of the laws and ordinances governing the weights and loads of vehicles, which covered those in effect in eight states and 49 cities in this country and Europe. Among the most uptodate of these ordinances Mr. Stern listed the following:

CHICAGO, ILL.:

Maximum weight of vehicle	15 tons
Maximum load on any one axle	12 tons
Maximum load on the wheel	6 tons
Maximum load per inch width of tire	1,000 lb.
Maximum length	40 ft
Maximum width	8 ft. 6 in.

Speed: Compatible with safety, but not to exceed 9 mi. per hr. Not to exceed 4 mi. per hr. when truck has defective tire that would cause injury to pavement.
Motor trucks must have rubber tires.
Trailers must have steel tires.

NEW YORK STATE:	
Maximum weight of vehicle	14 tons
Maximum load on any one axle	9 tons
Maximum load per inch width	800 lb.
Maximum width (except traction engines, which may have a width of 9 ft. 2 in.)	8 ft. 4 in.
Speed: Over 4 tons, 15 mi. per hr.; over 6 tons, 6 mi. per hr. with steel tires, 12 mi. per hr. with rubber tires.	
STATE OF NEW JERSEY:	
Maximum weight of vehicle	12½ tons
Maximum load per inch width of tire	800 lb.
Speed: 4 tons, 12 mi. per hr. with iron tires; 6 tons, 8 mi. per hr. with iron tires, 10 mi. per hr. with rubber tires.	
STATE OF PENNSYLVANIA:	
Maximum weight of vehicle	12 tons
Maximum load on any one axle	9 tons
Maximum load per inch width of tire	750 lb.
Maximum width, 7 ft. 6 in.; for busses in large cities, 8 ft. 4 in.	
STATE OF MASSACHUSETTS:	
Maximum weight of vehicle	14 tons
Maximum load per inch width of tire (except for hard pavements)	800 lb.
Speed: 4 tons, 15 mi. per hr.; 6 tons, 6 mi. per hr. with iron or steel tires, 12 mi. per hr. with rubber or similar tires.	
OAKLAND, CALIF.:	
Maximum weight of vehicle	14 tons
Maximum load per inch width of tire (except for hard pavements)	800 lb.
Speed: 4 tons, 6 mi. per hr. with iron or steel tires; 12 mi. per hr. with rubber tires.	
ENGLAND:	
The English have much the most complete and scientific ordinances of any of those examined.	
Maximum weight of vehicle	12 tons
Maximum load on any one axle (for trailers, 4 tons)	8 tons
Maximum weight of vehicle without load	5 tons
Combined weight of motor car and trailer	6½ tons
Weight of axle to be proportioned to diameter of wheel.	
The load per inch width of tire (steel) shall be 840 lb. for wheels 3 ft. in diameter; and an additional allowance of 9⅓ lb. for every additional increase in diameter beyond 3 ft.; and for wheels less than 3 ft. in diameter, a deduction of 18⅔ lb. per inch width of tire for every inch less in diameter than 3 ft.	
Vehicles for military service limited as follows:	
Weight of car unladen	6 tons
Weight of car with trailer	8 tons
Unit of registered axle weight with tires shod with crossbars	560 lb
Maximum width, 90 in. for 3 tons; 90 in. for trailer.	
Speed: Dependent on axle weight for iron-tired vehicles; 6 tons, 12 mi. per hr. for rubber tires; over 6 tons, 8 mi. per hr. for rubber tires; should car unladen weigh more than 3 tons, speed is limited to 8 mi. per hr.; if motor draws trailer, maximum speed is 5 mi. per hr.	

The points that Mr. Stern considered should be covered by such a law are: (1) The load; the diameter of the wheel; the width of tire; whether or not the tire is of a resilient material such as rubber, or of steel; the kind of springs. (2) Speed.

The Human Factor in Industry*

By F. H. Newell†

The engineer, if true to his name, is the man of ingenuity. He has made the strength of one man equal to that of a hundred of his forefathers. His machines perform the intricate tasks that a generation ago required the skill of a score of workers. He has rendered it possible for millions to live and to find work in the narrow confines of a city, by providing the machinery to bring them food and other necessities of daily life.

The human units, under this development of mechanical efficiency, have attained a wonderful efficiency in production of more things at cheaper prices. But success in this direction has been accompanied by serious defects of which the engineer is rapidly becoming aware. The fruit in hand has crumbled to ashes. What profits it if the world of *things* is gained to the loss by the many of their higher life?

The present unrest among the industrial workers is evident. Many fail to recognize, however, that this is the necessary outgrowth of the work of the engineer concentrated on narrow lines.

In many industries the investment in machinery and equipment represents roughly 50% of the outlay; the amount expended for labor is approximately equal. The engineer has been educated to think almost exclusively in terms of machinery and equipment. Absorbed in these details he has apparently overlooked the obvious fact that there is a limit to the effective working of this machinery, and that limit is set not by the inventor, but by the man who must operate it. The relative efficiency on the part of the improved machines may be 80 or 90% of perfection, while that from the human side may be as low as 20%.

Here, then, is a lack of proper balance. It is of no avail to secure 1% or 2% increase by throwing out the old and procuring better machines, if there is a persistent loss ten times as great on the labor side. It is becoming evident that, if the engineer is to continue to add to the health, comfort and prosperity of mankind through more inventions, it will be by a larger recognition of the fact that these inventions must aid the men who use them to progress upward rather than downward.

The application of economic laws to human welfare in industry is far more complicated and subject to more exceptions than the application of physical laws to engineering, yet these laws are as ascertainable as those which govern the action and reaction of the so-called forces of nature.

Engineers are awakening to the fact that they have a duty as well as an opportunity, and they are getting down to specific details. The progress is illustrated by the work done by the United States Reclamation Service. Beginning with the necessity of providing medical and surgical aid to its laborers in remote construction camps, it has taken up not merely the proper feeding, but also the housing of its men and their families—in some cases providing schoolrooms and lending a hand in social activities that tend to keep the men not only on the job, but also at their best.

These and similar lines of work were not dreamed of at the time the Reclamation Act was passed. They were regarded as wholly outside the domain of engineering. Today the responsible man in immediate charge of construction regards it as an essential part of his work, as well as a privilege. He can show, in his final statement of cost compared to output, economy in the expenditure of time and money in ways that a generation ago would have been regarded as purely altruistic and inconsequential. We are no longer compelled to defend this new emphasis on the human factor, but on the contrary we may properly apologize for doing too little rather than too much. We now know that the efficiency and economy of the final results depend not alone on properly cared for machinery, but on the welfare of the men and women who use it.

*Extract from an address before the Congress of Human Engineering, Columbus, Ohio, Oct. 26, 1916.

†Professor of Civil Engineering, University of Illinois, Champaign, Ill.

State Highway Maintenance Cannot be Forced according to county court decision in Pennsylvania in a case where the county commissioners sought a mandamus on the State Highway Department to compel the state to construct and maintain a road between Nazareth and Bethlehem. The judge held the state highway act of 1911-'13 requires the repair and maintenance of highways incorporated in the state system "only in cases where the state formally takes over this duty and assumes responsibility."

Engineering Literature

Engineers as Readers and Writers of Fiction

By R. Fleming*

In reading fiction an engineer's professional experience enables him to appreciate some passages that a reader without technical training would pass unnoticed.

In Kipling's story, "The Ship That Found Herself," the Scotch captain who is showing the owner's daughter around the new and untried vessel says:

> But it's this way wi' ships, Miss Frazier. She's all here, but the parts of her have not learned to work together yet. They've had no chance. . . . Every part of her, ye'll understand, has to be livened up and made to work wi' its neighbor—sweetenin' her, we call it technically. . . . For a ship, ye'll obsairve, Miss Frazier, is in no sense a reegid body closed at both ends. She's a highly complex structure o' various an' conflictin' strains, wi' tissues that must give an' tak' accordin' to her personal modulus of elasteecity.

Here may be the answer to the question, Why do some structures stand? The principles of mechanics are ignored, indeterminate stresses and redundant members abound, and yet the structure does not fail. The members of the structure adjust themselves to work together, each to its "personal modulus of elasteecity."

There is a passage in "Pickwick Papers":

> That's the wery prudentist resolution as you could come to, sir, replied Mr. Weller. You rayther want somebody to look arter you, sir, wen your judgment goes out a wisitin'.

Mr. Pickwick had found himself in a most embarrassing situation because his judgment had gone visiting. How many mistakes of engineers, good and reliable men, are explained by the simple statement that their judgment went visiting. One engineer estimated the "typical floor" as a single floor; another used a table of areas instead of a table of weights; another scaled drawings with a wrong scale—all three allowed their judgment to go visiting.

In "The Turnstile," a recent novel by A. E. W. Mason, a member of the English Parliament is thus addressed:

> You must all know that a man who is any use at all does change his opinions as his experience widens. Surely that's true. What's the use of thought at all if it leaves you precisely where you were? . . . And why, when he has risen, doesn't he say: "Of course I have changed my views. I am a better man than I was two years ago."

Of course! This may explain why the answer to a problem in a textbook on reinforced concrete is given differently in two editions, or why tension in the anchor bolts of a steel stack is treated in three ways in as many editions of a standard book on steel structures. These writers became wiser men in the two years or so between the different editions.

An eminent professor writing of beam flexure followed the accepted theory that the neutral axis of a section (symmetrical or unsymmetrical) passes through the center of gravity of the section. In the second edition of his book he located the neutral axis so as to make the moments of the horizontal forces on the two sides equal. In later editions he came back to the accepted theory as given in the first edition. Was there a growth or a retardation in the professor when he wrote the second edition? Or did his judgment go visiting?

It is seldom that marked mathematical ability and unusual imaginative powers are found in the same writer. Yet Rev. C. L. Dodgson and Lewis Carroll are the same person. It seems hardly credible that he wrote both "An Elementary Treatise on Determinants" and "Alice in Wonderland." But note how the mathematician betrays himself in that delightful children's classic, "Alice in Wonderland." At the tea party Alice is asked to take some more tea:

> "I've had nothing yet," Alice replied in an offended tone, "so I can't take more."
>
> "You mean you can't take less," said the Hatter; "it's very easy to take more than nothing."

It may not be generally known that Rankine wrote a volume of "Songs and Fables."[1] There is a fine blending of mechanics and humor in the introductory poem, "The Mathematician in Love." "The Three-Foot Rule" is a skit against the adoption of the metric system. The "Fables" are short and amusing. The "Goat and Compasses" is one:

> A pair of compasses, belonging to a geographer, was lying on a table, when a goat, happening to pass by, addressed to it the following taunt: "Your limbs serve but to straddle across a piece of paper, mine, to bound over the mountains."
>
> "Your limbs," replied the instrument, "enable one wretched animal to seek its food; mine assist a sage to map the world."
>
> Moral—Science, though despised by the ignorant, is better than bodily strength.

The engineer will have his horizon broadened, his youth renewed and his life prolonged by frequent incursions into the realm of the best fiction. It may not help him to make a better living in the way that phrase is usually interpreted, but it will help him to new sources of pleasure in his life.

*American Bridge Co., 30 Church St., New York City.

REVIEWS AND NOTES

Centrifugal Pump Practice

Reviewed by H. E. Longwell*

CENTRIFUGAL PUMPS AND SUCTION DREDGERS—By E. W. Sargeant. Philadelphia: J. B. Lippincott Co. Cloth; 6x9 in.; pp. viii + 188; 160 illustrations, including 14 folding plates. $3.25.

A little book so modest and unpretentious as to disarm hostile criticism. The reader will easily recognize the author as belonging to the older school of engineers, who followed their respective specialties from the drafting board, through the pattern shop, foundry and machine shop into actual service.

The work is in no sense profound. On the contrary it is essentially a simple and readable description of methods and constructions that have worked out satisfactorily in widely diversified centrifugal pump practice.

[1] It is to be regretted that this little book is not more accessible. The writer knows of but one copy in the United States—that owned by the Boston Public Library.

*General Manager, The Westinghouse Air Spring Co., New Haven, Conn.

The principles of design laid down by the author are strictly empirical, being based on formulas deduced from tests of a number of pumps of known dimensions. This of course presupposes that the pumps tested represent the utmost possibilities in point of efficiency—an assumption that is perhaps hardly justifiable. However, the method has the advantage of being conservative and safe, even though so easy as not to be particularly stimulating.

A somewhat unusual feature in books of this character is Chapter VII, which touches on patterns for casings and runners and methods of molding them in sand and loam. These suggestions are not at all out of place, as centrifugal pump castings—especially in the larger sizes—have bothered a good many fairly well-experienced foundrymen. There are also in this chapter a few directions as to convenient methods of machining these castings.

The book deals briefly with the more modern developments of series pumps for unusually high heads, and parallel pumps for large capacities at high speeds. Various forms of charging or priming apparatus are described, and concise directions are given for carrying out tests. Considerable attention is given also to the important subject of the arrangement of piping and valves.

A fairly comprehensive treatment is given of the application of centrifugal pumping machinery to sundry specific purposes, such as drainage, irrigation, handling sewage, pumping out docks, salvaging wrecked vessels, fire service and dredging and conveying solids. There is a brief chapter on rotary air pumps, but the treatment of the subject is quite superficial and no attempt is made to go into the details of design.

American readers must bear in mind that in the numerous formulas and tables capacities are given in Imperial gallons, which are 20% larger than the measure which is standard in this country.

The book is copiously illustrated. Many of the illustrations are dimensioned and appear to be reproductions of scale drawings of actual machines.

On the whole the work is scarcely one that would be classed as a textbook. Its contents savor more of the general counsel of an engineer of broad practical experience. It would do excellent service as a corrective with which to temper the ultra-theoretical treatment that is often encountered in textbooks dealing with this subject.

Dissertations on Ozone

OZONE: Its Manufacture, Properties and Uses—By A. Vosmaer, Ph.D., M. Am. Inst. E. E. New York: D. Van Nostrand Co. Cloth; 6x9 in.; pp. xii + 197; 67 illustrations. $2.50 net.

Ten years ago the subject of ozone was a much more live matter for engineering study in this country than it is today. It has apparently taken a back seat as a universal sterilizer, in America at least, through the greater commercial development of such disinfecting processes as those employing chlorine gas, and ultra-violet light. Therefore Mr. Vosmaer's book at this moment is probably more of academic interest than practical service. Perhaps that condition explains some of the more outstanding peculiarities of the volume.

There is much within the covers of the book that is worthy of permanent record, but the author's statements of scientific fact and engineering development seem rather too meager in technical detail and limiting circumstance to be successfully applied by other workers in this field. Fact is curiously interwoven with mere opinion; and there is an obtrusive display of irrelevant discourse on the author's experimentation. The English in spots hides the thought. There is a multitude of three-page chapters. All of which points to the need of stricter editing of the text.

The author starts by discussing the history and nature of the gas, its occurrence, properties and identification. A second part deals with matters of manufacture. Ozone production as a side effect of chemical reactions and thermal processes is reviewed preliminary to taking up the use of electrical discharges. Spark, arc, and brush discharge are compared at length—always of course from the standpoint of ozone production, though it may seem to some that the digressions are rather far pursued. Then the effects of placing solid dielectrics between the discharge electrodes are described, with emphasis on the comparative uselessness of the older open-electrode systems.

A considerable part of the text is taken up by the notes on utilization of ozone in the purification of drinking water, air and industrial materials. The author laments the lack of American initiative that prevents wide utilization of ozone over here, but he fails to account for the large expenditures in generating the gas that have been indicated as necessary, the inherent difficulties of applying it, and the lack of any American demand (such as has been reported in Europe where ozone has been commercially employed) for sterilization as compared with reasonably complete disinfection of water, air, or industrial products.

Municipal Functions

PRINCIPLES AND METHODS OF MUNICIPAL ADMINISTRATION—By William Bennett Munro, Professor of Municipal Government in Harvard University. New York: The Macmillan Co. Cloth; 6x9 in.; pp. xi + 491. $2.25 net.

In this volume on the organization, work and method of the principal departments of American cities, Professor Munro has provided a valuable supplement to his excellent earlier books on "The Government of European Cities" and "The Government of American Cities." The present volume deals with the leading functions of municipalities as did the two other ones with their framework. For the general student who wishes to go farther afield, Professor Munro has already provided a useful "Bibliography of Municipal Government." (For reviews of the three earlier volumes just named see *Engineering News*, May 13, 1909, Apr. 17, 1913, and Dec. 16, 1915.)

The subject matter of the volume now before us is introduced by a chapter on the current demand for municipal efficiency. A second chapter which in a measure may be considered as introductory also reviews briefly the history, principles and practice of city planning. The author then takes up in order streets, water-supply, garbage disposal and related subjects, sewerage and sewage treatment, public lighting, the police, fire prevention and protection, and the administration of schools. The final chapter is devoted to financial questions.

Each of the main functions or departments indicated is presented from the viewpoint of the work to be done, the organization for such work, and the various methods of accomplishing the results to be obtained. Obviously, the treatment must be sketchy in a volume dealing with so many subjects and written presumably for students of municipal government in and out of college rather than for men or women who expect to follow any one of these subjects professionally.

Notwithstanding the limitations just stated, the author has succeeded admirably in presenting a general view of each of the municipal functions indicated. Here and there statements appear that to one versed in the technicalities of the subjects treated seem unhappily expressed and in a few cases actually misleading. For instance, we are told on page 107 that asphalt differs from certain other pavements previously described "in that it is not laid unit by unit, but in the sheet." Close by language is used that would lead any uninformed person (and presumably the book is for the uninformed) to think that asphalt pavements are laid on a foundation of broken stone. The paragraphs on bitulithic and on macadam are also likely to give wrong impressions to the uninitiated. In dealing with water waste the author makes the curious suggestion that it would be cheaper to buy fertilizer than to use so much water on lawns. Elsewhere reference is made to figures which the author says "prove very clearly that under a metered system much less water is used in the homes of the poor than in those of the well to do," overlooking the fact that meters or no meters the "poor" use less water than the "well to do."

All these are of course relatively minor blemishes that probably will do little harm among the class of readers for which the book was designed.

Industrial Electricity

HANDBOOK OF MACHINE-SHOP ELECTRICITY—By C. E. Clewell, Assistant Professor of Electrical Engineering, University of Pennsylvania. Leather; 4x7 in.; pp. xi + 461; 61 illustrations. $3.

This compact and concise encyclopedia of machine-shop electricity really can serve the engineering profession as a dictionary of industrial electricity. It obviously was carefully planned, and it is clearly written. The illustrations are all well chosen, and for the most part are particularly attractive. The few of inferior execution set off the others and disclose the advance of recent years in technique of publishing such books. The ground covered by the text includes industrial-machine nomenclature, circuits, fundamental laws, communication systems, power and lighting supply, measuring instruments and miscellaneous appliances.

Geodetic Survey Centennial

CENTENNIAL CELEBRATION OF THE UNITED STATES COAST AND GOEDETIC SURVEY, April 5 and 6, 1916. Washington, D. C.: The Survey. Leather; 7x10 in.; pp. 196; illustrated.

The very interesting papers and historical documents connected with the celebration of the 100th anniversary of the United States Coast and Geodetic Survey last April are brought together in permanent form in this volume. Regret is often expressed that so little attention is paid to the history of engineering achievements. It is a matter for congratulation, therefore, that some of the interesting history of the work of the Government's earliest scientific bureau is here made available to the profession.

Physics Uniquely Treated

CONCISE TECHNICAL PHYSICS—By J. Loring Arnold, Ph. D., Professor Electrical Engineering at New York University. New York: McGraw-Hill Book Co., Inc. Cloth; 6x9 in.; pp. v + 275; 294 illustrations. $2 net.

The chief claim of this new physics text is that it is short. Various novelties of treatment have been adopted to secure the desired brevity. They make the book attractive for either classroom or home use.

Standard Duties and Salaries for New York City Employees

STANDARD SPECIFICATIONS FOR PERSONAL SERVICE—Prepared by the Bureau of Standards for the Board of Estimate and Apportionment of the City of New York. Municipal Building, New York City. Paper; 7x10 in.; pp. 931.

This bulky volume represents what has thus far been accomplished in a herculean task; to wit, the classification of all the many thousand officers and employees of New York City, from the Mayor down to the common laborer. This work has been done by the Bureau of Standards, of which George L. Tirrell is Director, for the Board of Estimate and Apportionment. A statement concerning this task of standardizing duties and salaries was published in *Engineering News* of Jan. 14, 1915. The system has been in practical operation now for some 18 months and is comparatively simple. All the officers and employees of the city are first grouped in divisions called "services." There are sixteen of these services. Examples are: Executive, Professional, Investigational, Inspectional, Police, Fire, Skilled Trades. Each service is divided into subdivisions termed "groups." Under the professional service, for example, there are the Accountant group, Architect group, Bacteriologist group, Engineer group, Pathologist group, Physician group, etc. Each group may be divided into grades according to its relative importance and the number of employees it contains. There are six grades, for instance, in the Engineer group. Under each grade are stated the titles of the different positions, and the duties, qualifications and compensation, with any special regulations governing compensation. A grade itself may be divided according to the class of work performed in it; for example, under Grade 3 of the Engineer group some of the positions classified are (1) Assistant Engineer, (2) Assistant Engineer, Civil, (3) Assistant Engineer, Mechanical, (4) Electrical, (5) Sanitary, (6) Power-plant Supervision. The rates of salary for this group vary from $2,280 per annum to $3,180 per annum.

Here, as practically everywhere else in the classified service, the idea is that persons entering the service in a certain grade will do so at the lowest salary rate and will be promoted to receive larger salaries year by year as they gain in experience, even though they remain in the same grade. It is the expectation, apparently, that the best men in each grade will so demonstrate their ability as to justify their promotion to the next higher grade.

Everyone has heard the chronic kicker declaring that the money which a city raises in taxes is spent in paying extravagant wages and salaries to a lot of idle fellows who hold their places by political pull and who would not be tolerated for a day if employed by a private business firm. Those who make such criticisms as a rule have no conception of the other side of the picture—the amount of faithful, hard work, year in and year out, given by men in the municipal service who work often for lower wages, less appreciation, and smaller prospect of bettering their condition than the average employee in a commercial concern.

Criticisms and kicks at the waste and inefficiency of city service have been in circulation time out of mind in cities without number; but the New York City government is the first, so far as we are aware, to undertake a broad constructive plan to better the conditions of city employment by placing it on a systematic basis.

The aim is of course to create a business-like organization in which the pay and promotion of every man will be proportioned to the work which he performs; needless positions will be eliminated; and every competent employee will be encouraged to render better service by placing his pay and promotion on a definite basis.

The size of the volume attests the magnitude of the task. The payroll of New York City is far larger than that of any other city in the world.

Before the Bureau of Standards undertook this work, the city's payroll had been increasing steadily at the rate of $2,000,000 to $2,500,000 a year. In 1915, as a result of the work of standardization, checking salary increases, etc., the city's payroll was reduced more than $300,000. In preparing the budget for 1916, when a more sweeping application of the standard system was made, many salaries lower than the standard rates were raised, and many positions found to be unnecessary were abolished. The saving made was over $600,000.

It is of course too much to expect that any system of this sort can of itself produce efficiency and industry, or can prevent money from being wasted in payment for unnecessary service or service slovenly performed. It is apparent, however, that without some systematic grading of employees such as has been here undertaken, those at the head of a city's government are practically helpless to produce the good results in the way of a businesslike administration, which is always promised in the election campaign but seldom performed.

In the introduction to the volume the basis on which salary rates are fixed is explained. A large amount of data was obtained as to the salaries and wages paid by prominent business corporations, also compensation paid by the Federal Government and by other large cities, especially where some sort of scientific method had been used in fixing the salary rate. Director Tirrell then reviews the conditions of employment in Government service, adverse and favorable. It is of interest to quote his statement that, "excepting a relatively small number of positions, the city service is not at the present time attractive to the best talent. Advancement and promotion are slow, and it is generally believed that they are not based solely upon merit. . . . Many branches of private business offer far greater opportunities for conspicuous material success than Government employment. . . . It is necessary for the city to pay higher rates than those paid in the most progressive private employments, if it is hoped to attract and retain equally competent men."

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A valuable aid to the water-works engineer is the new index of the "Transactions" (1883-1885) and the "Journal" (1882-1915) of the New England Water-Works Association. This is a 123-page booklet containing subject and author references to a veritable mine of data on water-works practice. While the early volumes of the "Journal" are rare, it would seem that most of the engineering libraries are supplied with files of the issues since 1890, so that the greater part of the references would be accessible to engineers in the larger cities. The index has been prepared for the Executive Committee by Richard K. Hale, editor of the "Journal." Copies may be obtained by nonmembers of the association for $1, by addressing the headquarters, 715 Tremont Temple, Boston, Mass.

Electrical Design for Students

PRINCIPLES OF ELECTRICAL DESIGN: D. C. and A. C. Generators—By Alfred Still, Fel. Am. Inst. E. E., Professor of Electrical Design, Purdue University. New York: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. xiv + 365; 146 illustrations. $3 net.

The practical designer of electrical equipment will not need this book, and his needs have been purposely neglected to emphasize fundamental ideas. The text obviously is not a compendium for the student either, but rather a convenient guide to be supplemented by lectures, further book study, and home work with design problems. The author's method seems to be so far as possible to proceed logically from fundamental principles, neglecting the practical short cuts which experience generally places in the practiced designer's hand, but employing empirical data and statements where advisable.

A unique feature of the book is the first or introductory chapter which gives some sound advice on qualifications to be cultivated by the student who aspires to be a good designer—on acquiring sound knowledge of engineering principles, respect for ability to draw and write, development of self-confidence, self-reliance and personality.

The course starts off with the magnetic circuit and electromagnets, then goes into direct-current dynamo-electric machinery and finally ends with alternators.

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Rochester Government

GOVERNMENT OF THE CITY OF ROCHESTER, N. Y.—General Survey, Critical Appraisal and Constructive Suggestions. Prepared for the Rochester Bureau of Municipal Research by the New York Bureau of Municipal Research. May-July, 1915. Paper; 6x9 in.; pp. 546; illustrated.

So complete an analysis as this of the operation of the municipal government of a typical American city is sure to prove most instructive and valuable to all who are interested in promoting efficiency in public affairs. The study is the more interesting because Rochester has, like many other Eastern cities, an old-style charter which provides for a single executive and a large council. The investigators have come to the conclusion that this form of charter is not essentially bad, and that a great many improvements in the line of efficiency could be made without changing the charter.

Notwithstanding criticisms which point to many defects in the organization and administration of the city government, the statement is made that the New York Bureau of Municipal Research, after an administrative study of some fifty different municipal governments and a comprehensive study of twenty-five, has decided that in Rochester the results and conditions are superior to those which have been found in any other city investigated. Where other old-type single executive, council-managed governments have broken down, this particular one has held together and done its work well.

The report is made up in exactly the reverse order in which most such documents are written. For the conclusion of the report, in the form of suggestions which can be made effective with and without charter change, form the first two chapters. The tenor of the whole criticism seems to be lack of coördination and lack of definite and single-headed responsibility. Work and responsibility which should be centralized is now divided among several bureaus more or less independent.

An entire reorganization of the Department of Public Works is recommended under a commissioner, with the

city engineer made chief engineer of the Department. The Department would then be subdivided into bureaus, whose heads would be appointed by and be responsible to the commissioner, instead of being independent and responsible only to the mayor and council as at present.

Most of the suggestions are sufficiently general in character to apply to almost any other city-engineering organization, and if generally accepted would undoubtedly promote centralization and efficiency in any organization. One recommendation, however, regarding record maps and plans might well meet with some opposition from engineering departments. This is the recommendation that all record plans now kept by the engineering department should be divided up and filed with the different bureaus, as water-works, sewerage, etc.

The wisdom of this recommendation is well open to question, for there is no valid reason why there should not be a concentration of engineering records and data as well as of work and authority. The original plans—tracings—should certainly be kept with the bureau where they originated, and where they are most likely to be wanted for reference and correction. If it is necessary for the different bureaus to have copies for their records, this could easily be arranged, but it would seem far better to centralize the responsibility for keeping the city engineering records in available shape, and much more consistent with the general tenor of the recommendations.

Steinmetz Continues Revision

THEORY AND CALCULATION OF ALTERNATING-CURRENT PHENOMENA—By Charles Proteus Steinmetz, A. M., Ph. D. Fifth edition, thoroughly revised and entirely reset. New York: McGraw-Hill Book Co. Cloth; 6x10 in.; pp. 480; illustrated. $4 net.

The joint revision of Steinmetz's well-known "Elements of Electrical Engineering" and "Alternating Current Phenomena" was mentioned in these columns (May 18, 1916), on the appearance of the new edition of the first named work. It was then noted how the great expansion of electrical science and art had necessitated recasting the two books on new lines and putting some of the new material that had been made available into another, a third, number of the series.

The volume now at hand retains the old title "Theory and Calculation of Alternating-Current Phenomena," but the text shows limitation to discussions only of the more common and general phenomena and equipment—instantaneous values, vector representation, symbolic method, polar diagrams, properties of circuits, eddy currents, dielectric losses, transformers, induction motors and generators, reactions in synchronous machines, general waves, and polyphase power systems.

Estimate and Payroll Tables

STANDARD IMPROVED RATE TABLES—For Manufacturers, Engineers, Bankers, Brokers, Contractors and Shippers—Calculated by John W. Marshall. The Most Rapid Tables in the World for Finding Wage Earnings by Any Unit or Fraction Thereof, and for Any Length of Time. New York: Boorum & Pease Co. Cloth; 7x9 in.; pp. 80. $4.

Rate tables are useful in computing earthwork and concrete, and in preparing monthly estimates, as well as in making up the payroll.

Each leaf of "Standard" rate tables contains two tables; on the front side total amounts are given at a full cent rate, while on the reverse side the amounts are given for a half-cent rate. The total amounts are given from one-quarter unit to 200 units.

Iron and Steel Mysteries

THE PHYSICO-CHEMICAL PROPERTIES OF STEEL—By C. A. Edwards, D.Sc., Professor of Metallurgy, Manchester University. Cloth; 6x9 in.; pp. x + 229; 181 illustrations. $3.50 net.

To the engineer ambitious to know more of the mysteries of iron and steel, a stimulative introduction into the subject of chemistry and structure is offered by the new work of C. A. Edwards. It appears mainly a fairly full discussion of the iron-carbon alloys, and in this part particularly is valuable for its wealth of references. Alloy steels do not seem to be as comprehensively treated. In this field and in the mill and shop field the book gives much less than the worker in the respective fields will look for. A large number of photomicrographs illustrates the structure of carbon steel.

New Art of Power-Belt Design

POWER TRANSMISSION BY LEATHER BELTING—By Robert Thurston Kent, Jun. Am. Soc. M. E., Consulting Engineer. New York: John Wiley & Sons. [Wiley Engineering Series.] Cloth; 5x8 in.; pp. vi + 114; 31 illustrations. $1.25 net.

The scientific refinement of machine-shop practice, wrought by the late F. W. Taylor and his associates, among its other effects has completely revised the old art of designing power-transmission belts. But so scattered in engineering journals and society publications has been the literature of this particular development that the average engineer has been ignorant of the change. This little book should alter that situation, and make the new knowledge accessible to all. The new schemes of design are highly logical, though of course employing empirical factors, compared with the crude rules of thumb which have heretofore prevailed. The new schemes usually call for heavier belts and lower tensions than the old formulas, but they result in a minimum annual cost—considering expense of repairs and maintenance and loss through breakages—as well as first cost.

Applied Electricity

APPLIED ELECTRICITY FOR PRACTICAL MEN—By Arthur J. Rowland, Professor of Electrical Engineering at Drexel Institute. New York: McGraw-Hill Book Co. Cloth; 5x8 in.; pp. xiv + 375; 323 illustrations. $2.

The better class of electrical texts for practical men are of great interest and importance to a wide variety of highly educated specialists—including of course the mechanical or civil engineer who comes in contact with electrical equipment at every turn though he never designs any of it. So it is that this book, though it is primarily intended for electrical workers, has a place in an engineer's library. One of its prominent features is the large use of numerical-computation problems to illustrate the action of apparatus.

The book starts off with "fundamental principles" and magnetic phenomena. Thus the road is paved for direct-current generators, heating and power service, distribution lines, and direct-current motors. Up to the close of this half of the work, nothing has been presented about alternating currents. For this field the author first goes back to elementary discussions of rudimentary matters like inductance, capacity, reactance, voltage and current waves, etc., preparing to carry the reader into such subjects as transformers, polyphase distribution, a.c. generators and motors. The end of the book covers storage batteries, electric lamps and house wiring.

The book is very readable and the discussions are helped by a moderate use of well selected illustrations.

Two new standard specifications for brick pavements have been issued by the National Paving Brick Manufacturers' Association under date of Sept. 1. They cover the two new approved methods of brick-pavement construction—brick laid on the green concrete foundation (monolithic construction) and the use of a dry sand-cement mixture in place of sand as a bedding or so-called cushion course. The specifications for laying brick on the green concrete foundation state that after the foundation has been laid and shaped in the usual way it "shall be brought to the required smoothness and condition for laying the brick thereon by adding thereto a thin coating of sand and cement." The following paragraph provides for the dry mixing of one part cement to three parts sand, and it is presumed that this mixture is applied dry to the foundation concrete, although the specifications do not definitely say so. The brick are laid, rolled and grouted as in ordinary practice.

The specifications for the "sand-cement superfoundation type" vary from the standard sand-cushion type chiefly in the "superfoundation," which is a dry mixture of 1:4 cement and sand, stone screenings or granulated slag. This bedding course is not over 1 in. in depth. It is struck off to a smooth surface and rolled with hand rollers before laying the brick. Copies of these specifications may be obtained by applying to Will P. Blair, Secretary, National Paving Brick Manufacturers' Association, Engineers' Building, Cleveland, Ohio.

So much interest has been manifested in the paper entitled "The Typhoid Toll," presented by George A. Johnson, Consulting Engineer, New York City, before the recent convention of the American Water-Works Association, that the association has decided to reprint it in the hope and expectancy that it will be bought and distributed in large numbers by water-works men and others interested in putting down typhoid fever. The price per copy up to 99 copies will be 20c. without, or 25c. with, the discussion; for 100 copies the prices will be $15 and $18.75; 100 to 500, $14 and $17.50 per 100; over 500, $12.50 and $15.75. Orders should be addressed to John M. Diven, Secretary, American Water-Works Association, 47 State St., Troy, N. Y. The paper reviews the causes and means of prevention of typhoid fever, with special relation to public water-supplies. It fills 77 pages, and is followed by an equal number of pages of oral and written discussions by many engineers and sanitarians.

Any one desiring information on autogenous welding of steel pipe by the oxyacetylene process should secure the new edition of Bulletin 26 of the National Tube Co., Pittsburgh, Penn. This bulletin gives the history and technology of such work by an extensive reprinting of noteworthy papers. Use of welded gas mains and piping in general is treated. Efficiency, cost and strength of welded joints are discussed.

The sections on cement, lime, sand and gravel and on asphalt, etc., have been reprinted separately from "Mineral Resources of the United States, 1915," published by the United States Geological Survey, Washington, D. C.

NEW PUBLICATIONS

[So far as possible the name of each publisher of books or pamphlets listed in these columns is given in each entry. If the book or pamphlet is for sale and the price is known by the editor, the price is stated in each entry. Where no price is given it does not necessarily follow that the book or pamphlet can be obtained without cost. Many, but not all, of the pamphlets, however, can be secured without cost, at least by inclosing postage. Persons who are in doubt as to the means to be pursued to obtain copies of the publications listed in these columns should apply for information to the stated publisher, or in case of books or papers privately printed, then to the author or other person indicated in the notice.]

THE ANALYSIS OF COPPER AND ITS ORES AND ALLOYS—By George L. Heath, M. Am. Inst. M. E., Chief Chemist, Calumet & Hecla Smelting Works. New York: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. vii + 292; 20 illustrations. $3 net.

ANNUAL REPORT OF THE QUEBEC STREAMS COMMISSION, 1915—Quebec, Canada: the Commission. Paper; 7x10 in.; pp. 109; illustrated.

AUSTRALIAN COMMONWEALTH DEMOGRAPHY, 1915 and Previous Years—Melbourne, Australia: Commonwealth Bureau of Census and Statistics. Population and Vital Statistics Bulletin No. 33. Paper; 8x13 in.; pp. 272. 5s.

AUTOMOBILE WELDING WITH THE OXYACETYLENE FLAME: A Practical Treatise Covering the Repairing of Automobiles by Welding, with a Nontechnical Explanation of the Principles To Be Guided by in the Successful Welding of the Various Metals—By M. Keith Dunham. New York: Norman W. Henley Publishing Co. Leather; 4x6 in.; pp. 167; 65 illustrations. $1.

CHEMICAL STUDY OF ILLINOIS COALS—By S. W. Parr. Bulletin 3, Illinois Coal Mining Investigations, conducted jointly by United States Bureau of Mines, State Geological Survey and Engineering Experiment Station, University of Illinois. Urbana, Ill.: State Geological Survey. Paper; 6x9 in.; pp. 86; illustrated.

GAS, OIL AND PETROL ENGINES, Including Gas-Producing Plant and Humphrey Explosion Pumps—By A. Garrard. New York: Whittaker & Co. Cloth; 5x8 in.; pp. viii + 221; 112 illustrations. $2.

GEOGRAPHIC TABLES AND FORMULAS—Compiled by Samuel S. Gannett. Fourth edition. Washington, D. C.: United States Geological Survey. Bulletin 650. Paper; 6x9 in.; pp. 388; illustrated. 25c. per copy from Superintendent of Documents.

THE MEASUREMENT OF SILT-LADEN STREAMS—By Raymond C. Pierce. Washington, D. C.: United States Geological Survey. Water-Supply Paper 400-C. Paper; 6x9 in.; pp. 39x51; illustrated.

MECHANICAL EQUIPMENT OF BUILDINGS: A Reference Book for Engineers and Architects—By Louis Allen Harding, B. S., M. E., M. Am. Soc. M. E.; and Arthur Cutts Willard, S. B., formerly Assistant Professor of Mechanical Engineering, George Washington University, and Sanitary and Heating Engineer, United States War Department. New York: John Wiley & Sons. Leather; 7x9 in.; pp. 615; illustrated. $4 net.

MELTING ALUMINUM CHIPS—By H. W. Gillett and G. M. James. Washington, D. C.: United States Bureau of Mines. Bulletin 108, Mineral Technology 14. Paper; 6x9 in.; pp. 88. 10c. a copy from the Superintendent of Documents.

THE MODEL T FORD CAR: Its Construction, Operation and Repair—By Victor W. Page, Member of the Society of Automobile Engineers; author of "The Modern Gasoline Automobile." New York: Norman W. Henley Publishing Co. Cloth; 5x8 in.; pp. 228; 94 illustrations. $1.

MORTALITY STATISTICS, 1914—Washington, D. C.: Bureau of the Census. Cloth; 9x12 in.; pp. 714.

NEW YORK STATE DEPARTMENT OF HEALTH: Report for the Year Ended Dec. 31, 1914. Albany, New York. Cloth; 6x9 in. Vol. I, General Information. Pp. 876; illustrated. Vol. II, Report of the Sanitary Engineering Division. Pp. 502.

PARKS: Their Design, Equipment and Use—By George Burnap, B. S., M. A., Landscape Architect of Public Buildings and Grounds, Washington, D. C., Lecturer in Landscape Design, University of Pennsylvania, Special Lecturer, University of Illinois; with an Introduction by Richard B. Watrous, Secretary American Civic Association. Philadelphia, Penn.: J. B. Lippincott Co. Cloth; 7x10 in.; pp. 310; 163 halftones and 4 diagrams. $6 net.

PASSENGER TERMINALS AND TRAINS—By John A. Droege, General Superintendent, New York, New Haven & Hartford R.R. New York: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. v + 410; 220 illustrations. $5.

PROBLEMS IN PHYSICS FOR TECHNICAL SCHOOLS, COLLEGES AND UNIVERSITIES—By William D. Henderson, Ph. D., Associate Professor of Physics, University of Michigan. New York: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. viii + 205; 167 illustrations. $1.50 net.

THE PURPOSES OF THE INDEBTEDNESS OF AMERICAN CITIES, 1880-1912—New York (261 Broadway): Bureau of Municipal Research and Training School for Public Service. No. 75, July, 1916. Paper; 6x9 in.; pp. 72. $1.

SEVENTH ANNUAL REPORT OF THE BOARD OF SUPERVISING ENGINEERS, CHICAGO TRACTION, Covering the Fiscal Year Ended Jan. 31, 1914—Cloth; 6x9 in.; iv + 277; illustrated.

A STUDY OF THE BEHAVIOR OF RAPID SAND FILTERS SUBJECTED TO THE HIGH-VELOCITY METHOD OF WASHING—By Joseph W. Ellms, M. Am. Soc. C. E., and John S. Gettrust. With Discussion. Reprinted from "Trans." Am. Soc. C. E. Vol. LXXX, p. 1342 (1916). New York. Paper; 6x9 in.; pp. 1342-1428; illustrated.

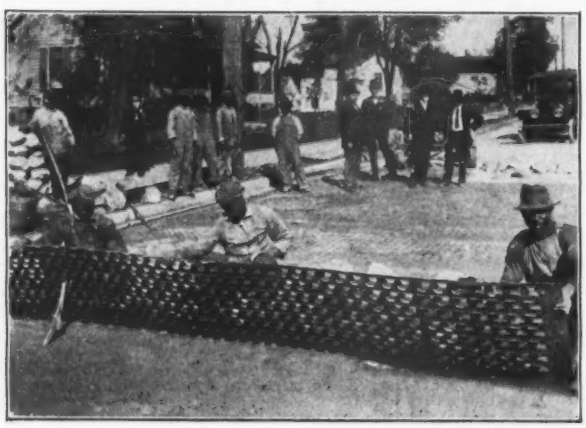
Notes from Field and Office

Charlotte tries sheet-steel paving—New York Central's experience with an electric tie tamper—Types of dumping trestle on 50-mile Southern relocation—Part sand plays in concrete failure—How one big New York contractor timbers and excavates the new subways—Pile jetting practice on several railways

Sheet Steel for Paving

A steel-plate pavement is the latest innovation of the seekers after the "universal" and "perfect" pavement. It harks back to the early sixties, when cast-iron blocks were thought to solve the same problem, and were actually tried out on Cortlandt St., New York City.

The city to be famed for trying out steel-plate pavement is Charlotte, N. C. The pavement has been laid on West Ave., where a macadam roadway 7 in. thick is under construction; the gradient at this point is 4%. The following method was employed: The macadam was built up to within 3 in. of net grade, forming a base 4 in. thick, upon which was deposited concrete proportioned



STEEL PLATES LAID IN CONCRETE AS AN EXPERIMENTAL PAVEMENT IN CHARLOTTE, N. C.

1:2:4, which the largest aggregate not over ¾ in. in size. The surface was leveled with a strikeboard.

The wearing surface consists of steel plates 18 ft. long, 30 in. wide, and of No. 11 gage ⅛ in. thick, with trapezoidal-shaped perforations 2x1½x1¼ in. in size, spaced from 1 to 1½ in. apart. The shorter parallel side of each perforation is uncut, and the metal is bent down at right angles to form a projecting dovetail on the under side of the sheet. Along one side of each sheet, tongues or lugs 1 in. square are left at intervals of 6 in.; on the other side slots are spaced to correspond, forming a connection for adjacent sheets.

The steel sheets were placed in position and tamped to a solid bearing, with the tops flush with net grade. Each steel sheet was joined to the one already placed by raising the outer edge and slipping the tongues of the new sheet into corresponding slots of the other plate. The new sheet was then lowered, and at the same time pushed close to the other sheet. A space of about ⅛ in. was left between adjacent sheets. The accompanying view shows a sheet being lowered to place, also the finished pavement in the background.

The following items show the extent and actual cost of the work:

Area 18x80.34 ft., 160.68 sq.yd.	
Macadam base 4 in. thick	$48.00
Concrete materials	61.90
Steel surfacing	180.77
Labor, including supervision	40.00
Total cost	$330.67
Unit cost, $2.06 per sq.yd.	

The steel cost $50 per ton; cement $2.60 per bbl.; crushed stone $1.50 per cu.yd.; sand $1 per cu.yd.

The inventor and patentee of the pavement is J. F. Wixom, "a retired farmer," of Hammondsport, N. Y., who is quoted as stating that for an 18-ft. country road (for which the pavement is designed) the approximate cost of the steel plates would be around $10,000 or $12,000 per mile, and the estimated cost of getting the material on the ground and of the actual laying of the road is $5,000, which will total approximately $15,000 or $17,000 per mile. The city engineer of Charlotte, who has given the pavement a trial, is S. H. Lea.

Electric Track Tampers on the New York Central

By G. W. Vaughan*

An electric track tamper used in Germany was described in *Engineering News*, Mar. 16, page 515. On the same page is a column article dealing with electric, pneumatic and hand tamping of track ballast. Since seeing those articles it has been in my mind to comment briefly upon the German machine, and furnish further information on the Vaughan electric tamper. The accompanying views show the tamper in operation on the New York Central R.R.

Referring to the electric machine used in Germany, and which has been patented in the United States, I note from the photograph that the tamper evidently could not be used unless the ties were spaced farther apart than is the general American practice, and that in operating the machine the men have to bend over practically as much as if they were using a tamping pick.

The rate of progress of a gang of six men operating four of these machines on the Hamburg-Berlin line is given as 500 ft. per day, the cost per foot of track being 2.2 cents. The view in the Mar. 16 article, however, indicates that only one side of the tie was tamped, as is done when picks are used. Therefore, if these machines tamped both sides of the ties the cost would be double.

On account of the straight tamping bar and the position of the machine, it would seem that it would be impossible to use it to tamp switch ties or around switches and frogs or slip switches, where the ties are very close together. If I am right in this, the application of the machine would be limited to tracks where the ties are

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quite wide apart. There is no question that the machine will tamp ties providing the tamping bar is placed lower than the bottom of the tie, so as to drive the ballast under the tie.

In the Vaughan electric tamper, the motor of the machine, contained in a box on the side, drives the crank in the back of the casing. The crank moves a reciprocating cylinder within which is a free piston driven back and forth by the air compression in the cylinder and by a solenoid at the lower end of the tamper, the reciprocating cylinder shifting the magnetic field produced by the solenoid. The electric tamper weighs 86 lb. and the tamping bar 4 lb., making a total weight of 90 lb., and requiring two men to operate.

Fig. 1 shows a foreman and five men using these tampers on general section work. This foreman claims he would rather have this outfit in his gang than six additional men. I think, however, that this statement can be taken with a grain of salt, as I believe that if the machine is equal to four additional men on a section, that is all that could reasonably be expected of it. Fig. 2 shows the tamper in operation in the third-rail territory of the Electric Division, taking current from the third rail through resistance boxes shown at the right of the track. Fig. 3 shows the tamper in operation in connection with a generating set mounted on a handcar, which is equipped so that electric lights may be used when working in tunnels. Fig. 4 shows the electric generator.

At the present time there are a number of these tampers working on the Electric Division, taking power from the third rail, and on the Exterior Zone taking power from a generator car. The tampers are usually operated in sets of three, so that in case of accident there is a spare tamper with which to continue the work.

In tamping tracks two of these machines are operated simultaneously from opposite sides of the tie which means thorough tamping of the ties. This necessitates twice as much work as required by hand tamping, as in the latter case only one side of the tie is tamped. If both sides were tamped by hand, the second tamping would loosen up the ballast previously tamped. Where the machine tampers are used on opposite sides of the tie, the track will stay up longer and better than by any method of hand tamping. On the New York Central there is track that was tamped by machine in 1914 and has not been tamped since that time.

The cost of operating the Vaughan tamper, first by using a portable gasoline-engine-driven generator and second by taking current from the third rail through parallel resistances is as follows:

Cost of generator	$600.00
Cost of two tampers	400.00
Cost of two resistances, including contact boards, cables, etc	100.00

Depreciation and interest per day is figured on the assumption that the machines were used 180 working days per year.

TAMPERS OPERATED FROM GENERATOR

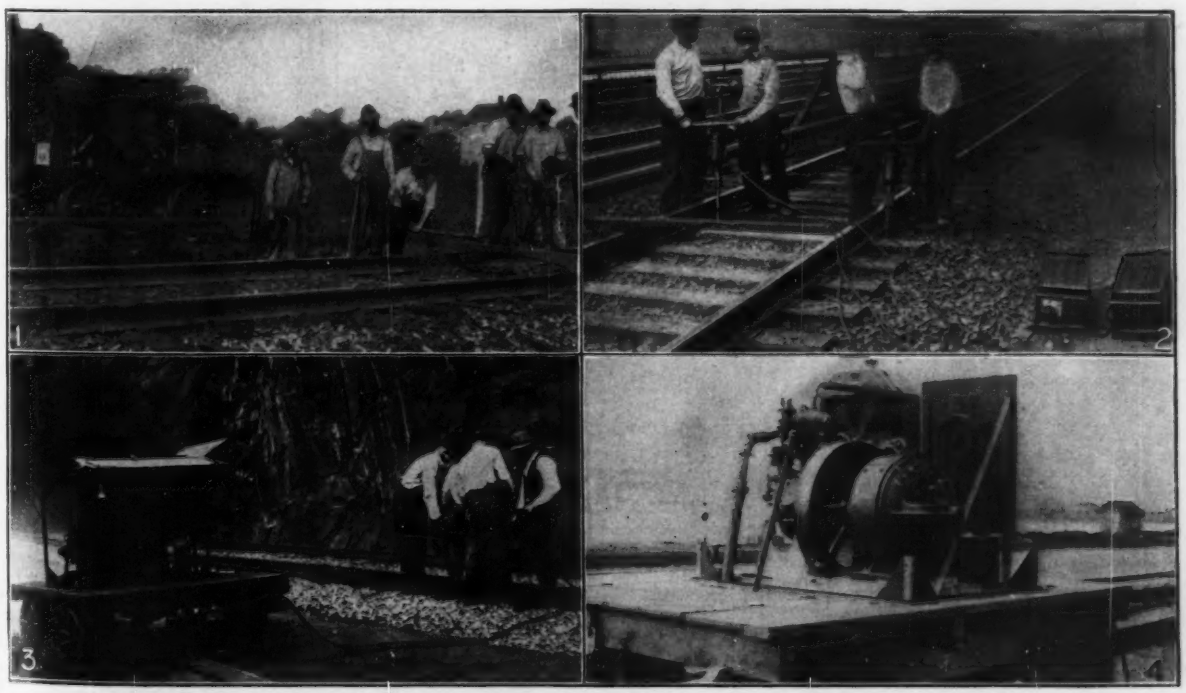
Operation		
Foreman, 10 hr	$0.27	$2.70
5 men, 50 hr	.19	9.50
Gasoline, 4 gal	.20	.80
Engine oil, ½ pint	.05	.03
Fixed Charges		
Depreciation (generator)	7½%	.25
Depreciation (two tampers)	10%	.22
Interest and maintenance (generator)	10%	.33
Interest and maintenance (two tampers)	15%	.33
Total cost per day		$14.16

Tamped on average 356 ft. per day.
Total cost per foot, $0.04.

TAMPERS OPERATED FROM THIRD RAIL

Operation		
Foreman, 10 hr	$0.27	$2.70
6 men, 60 hr	.19	11.40
Power, 96 kw.-hr	.01	.96
Fixed Charges		
Depreciation (2 tampers)	10%	.22
Depreciation (2 resistances)	7½%	.04
Interest and maintenance (2 tampers)	15%	.33
Interest and maintenance (2 resistances)	10%	.06
Total per day		$15.71

Tamped on average 356 ft. per day.
Total cost per foot, $0.044.



FIGS. 1 TO 4. VIEWS OF VAUGHAN ELECTRIC TAMPER AND POWER SUPPLY

Dumping Trestles Seen on the Southern Ry.

Railway fills are made chiefly by dumping from one or more lifts of trestle or by building one trestle and then jacking the track to grade. As is the case on most large grading jobs where several contractors are doing the work, both these methods are in use in grading the 50-mi. second-track Southern Ry. relocation between Central, S. C., and Cornelia, Ga. Some of the typical dumping trestles are shown herewith.

Half a mile south of Ayersville, Ga., the trestle for a fill on the new line is built on the side of the old 70-ft. fill. This trestle was not anchored very securely, as Figs. 2 and 5 indicate. In dumping, the 12-yd. cars were backed out on the trestle very carefully and just far enough to dump clear.

The timbers, which are obtained near the right-of-way, are hauled to place and hoisted by hand, by ox team or by mules. Fig. 1 shows the design of a trestle at Seneca, S. C., in which some of the bents were wired together. Some single-story bents that reach 70 ft. in height are shown in Fig. 4.

Two especially good examples of the trestle method and the jacking method are found on this work. The heaviest fill is 150 ft. high, and it has been carried up more than 60 ft., to date, by jacking the tracks from the first 18-ft. trestle lift. This work is near Toccoa, on the Lane section. Near Deercourt, Ga., a 105-ft. fill is being made from three parallel trestles of increasing height. This is on the Rinehart & Dennis section. This fill must be carried across a 30-ft. arch culvert at Walton's Creek. The 150-ft. fill is pierced by a 5-ft. arch culvert 533 ft. long, described in *Engineering News*, Nov. 2, p. 850. Both these large fills are almost entirely borrow.

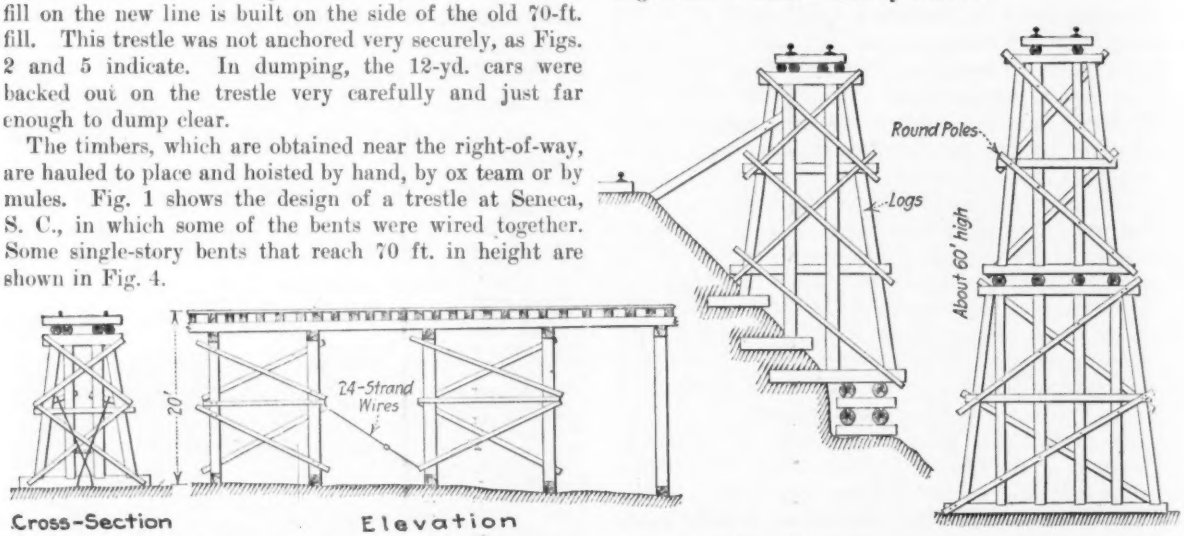


FIG. 1. TRESTLE AT SENECA, S. C., IN HEAVIEST FILL ON NORTHERN SECTION. FIG. 2. TRESTLE BUILT ON SLOPE OF OLD 70-FT. FILL. FIG. 3. TWO-STORY TRESTLE-BENT THREE MILES SOUTH OF TOCCOA, GA.

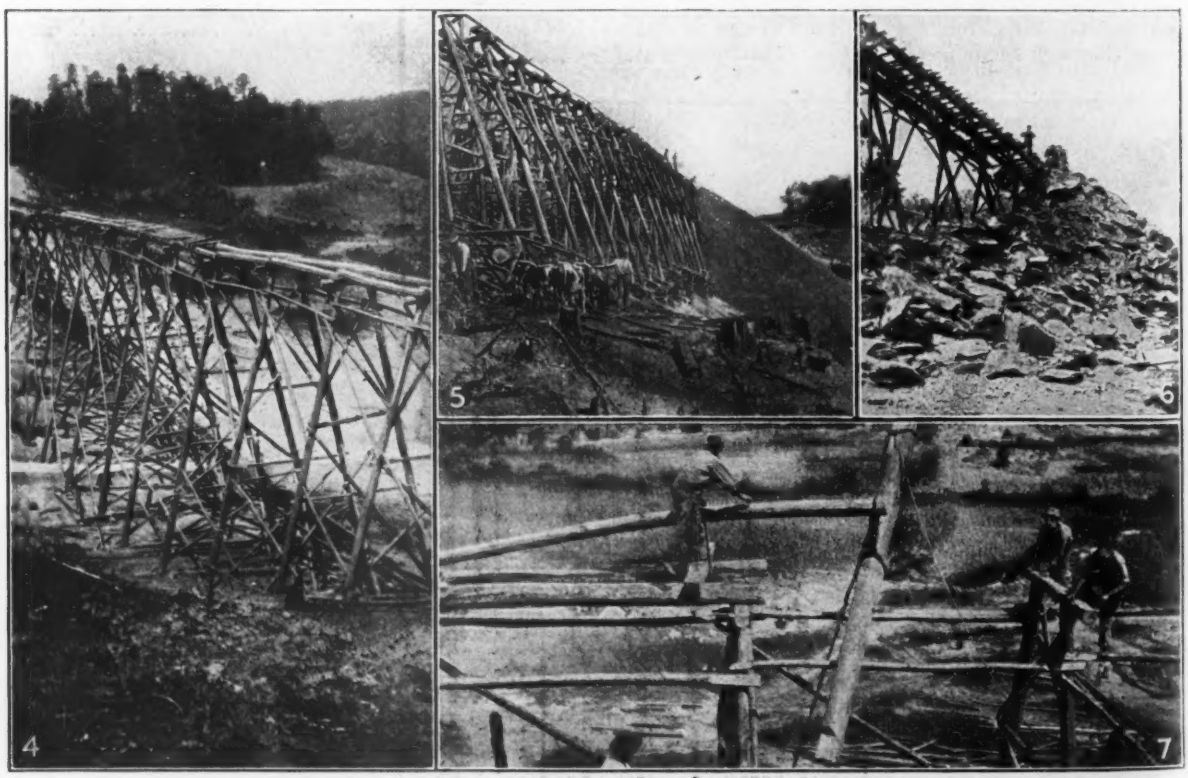


FIG. 4. HIGH TRESTLE WITH SINGLE-STORY BENTS. FIG. 5. BUILDING TRESTLE ON SIDE OF OLD FILL (SEE FIG. 2). FIG. 6. FILLING WITH ROCK. FIG. 7. ERECTING STRINGERS, USING MULE HOIST

Albany Engineers Discuss Sand

The increasing attention given to the quality of sand used in concrete was emphasized by D. A. Watt, Assistant Engineer, United States Engineer Department, Albany, at the "concrete meeting" held by the Albany Society of Civil Engineers on Oct. 24.

In all concrete failures that have come under Mr. Watt's observation it has been shown that bank sand was used. River sand seems to make a better concrete. It has been demonstrated that 5% silt increases the strength of concrete and that even 10% is not deleterious, but that beyond 10% the concrete becomes poorer.

Mr. Martin called attention to the fact that the presence of oxide of iron in sand retarded or actually prevented setting of concrete, depending upon the amount of the oxide present. It occurs as a hard reddish coating on the grains. This condition is found in Adirondack sand.

Quite a controversy arose on the subject of laitance and how far this feature of concrete work was due to the sand. H. S. Mattimore said that the State Highway Commission specifies coarse sand and that with this quality of sand and a drier mix than is common practice no trouble has been experienced with laitance.

Subway Steelwork Kept 20 Ft. Behind Heading

By George D. Fried*

On Section 4 (Routes 4 and 38) of the Seventh Ave. Subway between 12th and 13th St., New York City, progress in excavating was very much hampered after reaching groundwater—at 27 ft. below the street surface and about 9 ft. above subgrade of the subway. About 2 ft. below groundwater a mixture of very wet clay and fine sand was encountered having a bearing of approximately 4 tons per sq.ft. The subgrade of the trench was about 36 ft. below the street surface, and 90.5 ft. wide, where the completed subway has a four-track express station 500 ft. long. The distance between theoretical building lines is 100 ft., allowing only 4.75 ft. between neat lines of subway and building.

Excavating proceeded in four lifts, the first being from 10 to 15 ft. deep. This depth is practically the same as that of ordinary cellars and basements, the walls of which formed the sides of the excavation, thus affording easy access to the buildings for underpinning operations and eliminating also the necessity for sheetpiling. The second, third and fourth lifts were 24, 30 and 36 ft. respectively below the street surface.

Excavating was done with pitchforks and shovels. The muck was conveyed to the nearest shaft in 0.8-yd. buckets running on tracks on the finished floor.

Starting at the third lift, at points where the subway steel would not interfere, the street loading was transferred to four 30-in. 180-lb. 42-ft. longitudinal needle beams, as illustrated in Fig. 1. These I-beams were on 20-ft. centers, and from them were suspended 12x12 braces, as shown.

The needle beams, with 20 ft. of their forward ends resting on the third lift of the excavation and their rear ends supported on the finished floor of the subway, are the key to the timbering method, by which the finished structure was kept 20 ft. behind the heading face of the lowest lift. At the face 2-in. t. and g. sheeting was driven 3 ft. below subgrade and braced.

The posts adjacent to the heading—centered on the line of the temporary posts and having concrete footings extending 1 ft. 2 in. below subgrade to take the street load—were set before excavating the fourth lift. As soon

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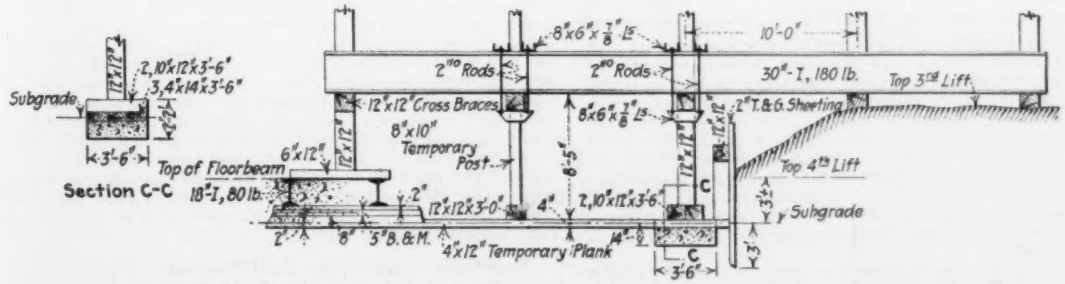


Fig. 1 Longitudinal Section

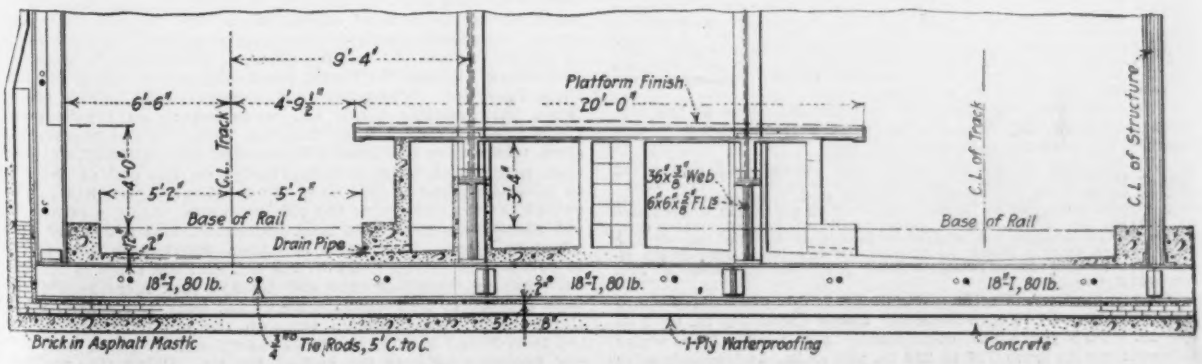


Fig. 2 Section of Completed Structure

NEEDLE-BEAM SYSTEM AND WORKING SPACE, AND CROSS-SECTION OF COMPLETED SUBWAY

as the excavation of the fourth lift reached the final subgrade, 4x12-in. plain rough planks were placed on the bottom in order to keep the water down as much as possible. This plank bottom was held in place by means of intermediate temporary wood posts on spread footings placed on 10-ft. centers transversely.

Just before placing the 8-in. concrete floor the planks and posts were removed. The waterproofing—one-ply fabric and 5 in. of brick in asphalt mastic—was placed on the floor concrete, and upon this was set the grillage consisting of transverse 18-in. 80-lb. I-beams, 5 ft. c. to c. longitudinally. These beams were concreted, and to them was transferred the load carried by the needle beams. The latter were then moved ahead 20 ft., to make ready for the next section.

At the inside column lines of the completed subway (Fig. 2), the 18-in. floor-beams carry 36-in. longitudinal girders 10 ft. long and 10 ft. 11 in. c. to c. transversely, weighing about one ton. These floor beams were not riveted until the bottom of the next 20-ft. section had been concreted, allowing the steel, which was set 1 in. high, to settle to grade. In only a few places was there any settlement below grade due to the vertical load forcing out the wet clay and fine sand on the bottom. This proved the effectiveness of the method safely to confine the running water and soil. Where the steel settled below grade, shim plates varying from 1¼ to ⅛ in. thick were placed on top of the 18-in. floor-beams, to insure the roof of the completed subway being set to the proper base-of-rail clearance.

The buildings were maintained against settlement or tranverse movements by driving 40-lb. arch-web steel sheetpiling 14 ft. below subgrade at subway neat lines, instead of the usual 4-in. t. and g. timber sheeting.

FINE AGGREGATE

Pile-Jetting Practice—In a recent investigation by the American Railway Bridge and Building Association on the subject of driving piles in railway construction it was found that the water jet is in successful use under proper conditions on about 50% of the 56 railways from which data were obtained. Some use it only with concrete piles, others for foundation piles or only with a marine piledriver. Only one failure is reported, and it is ascribed to the small size of the pump. Favorable conditions for jetting are sandy soil or gravel and deep penetration. The practice is fairly uniform, and that of the New York Central (Lines West) is typical. It is as follows:

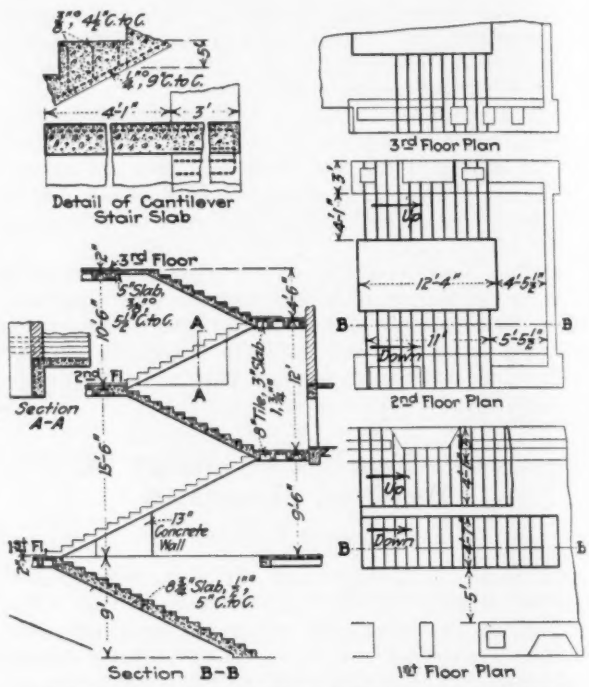
The water jet is sometimes used to put down piles in sand, where the track can be adequately safeguarded and where there is plenty of water and provision for the waste water to run away. For jetting, a pump of sufficient capacity is placed near a stream or other body of water, when at hand, or else on the piledriver tank. A 2½-in. hose is used with a 2-in. iron-pipe jet 30 to 40 ft. long, with the lower end drawn down to a diameter of about 1¼ in. to serve as a nozzle. For a 30-ft. pile the jet is so manipulated that the pile will go down about 25 ft. under the weight of the hammer, then driven the remaining 5 ft. to place.

The committee report states that the jet pipes of the different railways vary from 2½ to 1¼ in. The Chicago & Northwestern Ry. uses the following jet pipe:

A 2-in. pipe drawn out to a 1-in. nozzle, and somewhat longer than the depth to be penetrated, is used. The upper end is fitted with an elbow, a nipple and a loose connection to a duplex pump of sufficient capacity to maintain a pressure of 100 lb. per sq.in. in the pipe with an unobstructed flow through the nozzle. A separate line tied to the top of the pipe passes over a block to the top of the leads and down to the winchhead, furnishing means for readily raising and lowering the pipe.

On the Southern Pacific, difficult ground is penetrated using a pipe drawn out to a rectangular shape about 1¼ in. by 2 or 2½ in. Two jet pipes occasionally are used. The water pressure varies from 100 to 225 lb. per sq.in., and pumps with 3- or 4-in. discharge pipes are generally used. A large volume of water at moderate pressure gives the best results.

A Reinforced-Concrete Stairway cantilevering out from side walls was recently built for the residence of George Howe at Chestnut Hill, Philadelphia, by the Humphrey Construction Co. The owner of the house, an architect, had plans drawn in which stairs extended on opposite sides of a hall, leaving an open well down the middle. He particularly desired not to have columns on the outside edges of the stairs, so that it was necessary to tie them back by cantilevering to the brick walls. These brick walls were made 3 ft. thick and extended clear from basement to roof, and the stair was designed as shown in



CONCRETE CANTILEVER STAIRWAY IN RESIDENCE

the accompanying cut. In this design each riser and tread is figured as a separate cantilever beam 12 in. wide and 5 in. deep. Two openings in the brick wall precluded the proper bearing of the concrete on the brick, one because of a closet and the other for a fireplace. In these two cases the reinforced-concrete stair was turned at right angles and continued vertically down as a 13-in. concrete wall to the nearest floor, which was also of concrete joist construction; and the reinforcement from the stair was turned and tied down as a hook around the steel of the floor joist. The work was designed under the direction of Louis Muhlhausen, 1029 Brown St., Philadelphia, Penn., who was at that time engineer for the contracting company.

Repairing Narrow-Gage Steel Crossties—Steel crossties for mine use are expensive, and it has been found justifiable to spend considerable time and money in repairing old broken ones, according to C. W. Stafford, of Stone, Ky., in "Coal Age." He says the tie in most extensive use and the one that gets out of commission easiest has lugs punched from the body of the tie to form the rail fastenings. When a car is wrecked and dragged along the track, the flange of the wheel mashes these lugs flat. When the trackman attempts to straighten them, they usually break off, rendering an otherwise good tie useless. These broken ties are taken to the blacksmith shop, where they are repaired by one of two methods. By the first, a piece of ¼-in. iron is riveted on the end of the tie, to take the place of the lugs. Two holes are punched in the end of the tie, outside of the old lug holes. A piece of iron is cut about 3x3x¼ in. and bent so that it will admit the rail when in place. Two holes are then punched in this piece, to correspond to the holes in the tie, and the piece is riveted on. An improvement over the method just mentioned is to take a piece of iron about ¼x¼x6 in., neck it slightly, stick the head of this piece up through the old lug hole in the tie, turn it flat so that the head cannot slip out, and bend the end around and over the end of the tie. Using this method instead of the other saves about one-third the amount of metal required and saves also in time.

Editorials

Why Not a Better Joint for Water Mains?

Do water-works engineers ever stop to consider that the present type of bell-and-spigot water-main joint has undergone practically no change in a hundred years? Do they ever question whether the method of making a joint can be improved? If not, why not?

The committee of the New England Water-Works Association on leakage from pipe joints has clearly demonstrated that there is an enormous economic loss resulting from leaky water mains. This is an era of conservation, and the cause and prevention of this loss should be looked into.

The cause may be slippage of meters. If it is, there should be more accurate meters. But some part of the 20% unaccounted for water in city systems, and probably a large part, comes from leaky joints. Let water-works men turn to and give this matter a little study.

So far the committee has not been able to draw any conclusions as to whether it is economically possible to reduce the 20 to 30% water loss by a better type of joint, better workmanship, testing at pressures above normal, or in some other way. The information most needed to reach conclusions is that giving the results of leakage surveys, of actual tests made after the pipe has been in service some years, of experimental work showing the relation between pressure on the joints and leakage, and particularly data from those water departments where accurate tests have shown leakage in mains to exist. F. A. Barbour, Consulting Engineer, 1120 Tremont Building, Boston, Mass., is chairman of the committee.

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Patenting the Unpatentable

Another blow to patenting the unpatentable has been struck. This time patent claims on mechanical water filters have received the sort of death blow that has been delivered of late in a number of reinforced-concrete patent suits.

The case just decided involved the use of central operating control of valves, and also the use of screens between the sand and gravel, in the mechanical water-filtration plant of the City of Minneapolis, as stated on one of the last pages of this issue.

Two years ago a lower court threw out the same patentee's claims to control the combination of a filter bed above and a clear-water chamber below with means of forcing water up from the chamber through the bed, and denied some other claims as well; but although expressing doubts as to the validity of the central-control and the screen claims, the court lacked conviction or courage to declare them invalid also. By the recent reversal of the decision of the lower court, three filter patents, either wholly or in their leading claims, go by the board.

The marvel is not that these patent claims were declared invalid but that they were ever allowed. The same is true of some of the patents on reinforced concrete held invalid during the last year or so.

In effect, the courts have decided in what is now a respectable number of cases that the Patent Office has been putting its great seal on solemn declarations that John Smith, Richard Roe and James Doe have made new and useful inventions when all these gentlemen really did was to search current engineering design for some detail or combination that would give them a basis for patent and royalty claims. This is not invention. It may yield royalties. It is sure to cause litigation. Happily the many recent adverse court decisions will tend to discourage inventors, and perhaps the Patent Office, from attempting to patent the unpatentable.

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Record Dam and Turbines in Yadkin River Plant

An overfall dam 169 ft. high from top of toe to crest, and turbines of 31,000-hp. maximum capacity are outstanding features of the Yadkin River development, described elsewhere in this issue, that command immediate attention. But beyond these, this whole development is of unique interest, historically and in its details of design and construction.

Probably no important plant in the country has passed through more surprising vicissitudes and has had more radical revisions of its engineering plans than has this one, now safely approaching completion. To start with, there was a half million dollars or so spent in a beautiful long, low, cut-stone dam that was soon abandoned. Later owners laid out a higher dam lower down on the stream and a power house to contain the largest direct-current generators that had been designed. Then came a French aluminum company with a high non-overflow curved gravity-section dam and outlets for flood overflow through a couple of 60-ft. wells and tunnels. Finally appeared the present American owners with the great full-length overfall dam and record-breaking turbine units now under construction.

Designers will be interested particularly in the dam with its many contraction joints about 50 ft. apart, simply sealed by a multitude of tar-painted key grooves, and in the great pains taken to secure the completely grouted heel and fully vented base. The enormous yardage of concrete (525,000 cu.yd.) almost equals the record established at the Elephant Butte dam in New Mexico (600,000 cu.yd), although it is still much under the 850,000 cu.yd. in the Olive bridge (Ashokan) dam and the million odd yards at Kensico. The Yadkin dam appears, however, to be by a good margin the highest long overfall dam yet built anywhere.

Each case of the use of such enormous hydraulic turbines as employed here (27,000 hp. or 31,000 hp., according to the method used in rating) is always interesting and significant, but is not to be taken as an indication of a universal increase in the size of hydraulic turbines that are being commonly used. The field for smaller units is

as great as ever. It is not the height of desirability in the great majority of cases to concentrate the station capacity in a few units of such size. Only is it warranted, where, as here, the load is extremely well sustained and the total amount of power very large, so that such machines become feasible without sacrificing flexibility of operation and high light-load operating efficiency of the plant.

The turbine manufacturers have made a notable contribution to their art—with their huge plate casing, the big cast-bronze runner, the new scheme of dismantling and the simplification of bearings. The Holyoke test efficiency is very high, approximately 91%; and if it proves possible to get a good measurement of the water flowing through the station, it may be expected that a few more points will be added to this figure.

The contractor's work illustrates among other things the application of old industrial methods that may be widely utilized with profit by such concerns—such efforts as the standardization of working equipment to simplify maintenance and to increase familiarity of the working forces with all machines engaged on similar operations; or the concentration of concrete-mixing capacity in two maximum-size units for the reduction of number of mixer-plant tracks and for the reduction of time of loading and placing, where great speed is to be developed. Had the contractor on the Yadkin work not suffered the loss of his downstream tracks by the unprecedented floods that visited North Carolina in July, it is certain that he would have set a new high record for amount of concrete placed in one day, probably reaching as high even as 4,000 cu.yd or over.

In all respects, then, in history, in size and design of dam, in station layout, in design of turbines and in the contractor's equipment and methods, the Yadkin River work is remarkably significant and worthy of the careful scrutiny of engineers in all branches of the profession who desire to study the advancement of their art. In few plants indeed have so many important advances culminated on one job.

Greater Safeguards Needed for Drawbridge Openings

The shocking disaster at Boston on Nov. 7, when a crowded street car plunged to the bottom of the Fort Point channel at an open drawbridge and 46 persons imprisoned inside the car were drowned, ought to call attention everywhere to the need of more adequate protection at such danger points. This is the most serious drawbridge accident since the wreck at Atlantic City on Oct. 28, 1906, when a train was derailed at the drawbridge across the Thoroughfare just outside the city.

The investigation in the Atlantic City case promptly revealed the fact that the protection to the drawbridge opening was inadequate and did not conform to good practice in the art. Many years earlier, railway signal engineers had definitely established an equipment of home and distant signals interlocked with derailing switches and with the bridge operating mechanism as the standard protection for drawbridge openings on steam railways. The lack of this protection at Atlantic City cost the lives of 64 persons for whose deaths the railway was held financially responsible in a very large sum.

It may as well be frankly confessed that the protection of drawbridge openings on electric street railways is sadly deficient almost everywhere compared with steam railway practice. In many cities it has been taken for granted that because a street railway car normally runs at slow speed, a more or less flimsy gate at the drawbridge opening with a red lantern hung on it at night is all that is required to safeguard street cars and other vehicles from running into the opening left when the bridge is swung to permit river traffic to pass.

The Boston disaster proves the falsity of this assumption. The motorman did stop, according to the rule, at a street corner only 75 ft. from the edge of the drawbridge opening. The gate swung across the street when the bridge was open was 22 ft. back of the edge. There would seem to be on the face of it no reason why the motorman should not see this gate, little more than a car length ahead, with the red lantern hanging on it. The fact is, however, that he did not see it in time to apply the brake and stop the car before it plunged over the edge

Mayor Curley promptly announced that he "would call on experts from the Massachusetts Institute of Technology to aid the Public Works Department engineers in devising a signal or mechanism which will make it virtually impossible for even violators of the speed laws to go through open drawbridges."

There is no need, however, to invent new devices to accomplish this end. Methods and apparatus that have been long in use are ample to furnish the most complete protection that can be desired at such openings. Doubtless the best protection of a drawbridge opening is the use of the double bascule type of bridge, in which each half of the bridge when open stands erect and forms a substantial barrier across the opening.

For the protection of steam railway traffic across drawbridges, the derailing switch interlocked with the signals indicating the position of the drawbridge has been long established in steam railway practice as the standard protection by which every drawbridge opening should be guarded. For those who object that to derail a train at the back of a drawbridge opening is substituting a small risk for a large one, there is open the use of the sand track, in which the derail, instead of throwing the train onto the ties, turns it onto a stretch of track whose rails are covered with two or three inches of sand. This gives the same protection and practically eliminates the risk.

For the protection of street cars which are run at low speed and as single cars instead of trains, such protection of drawbridge openings by derailing switches is comparatively easy. Some provision must be made, of course, that the car when thrown off the rails shall have its speed effectually checked by a sand track or its equivalent in some form of paving that will absorb the energy of the car rolling over it.

Such safeguarding of drawbridge openings gives protection not merely against the careless motorman who fails to see the signal placed against him, but also against the risk that the motorman through sudden paralysis or similar cause may fail to apply the brakes at the proper time, and also against the risk that through some failure of the brake apparatus it may prove inoperative as the car approaches the opening.

The Longest Railway Tunnel in the World

In this issue of *Engineering News,* Gen. Henry M. Chittenden, of Seattle, describes the project which he has worked out with much painstaking detail for building a railway tunnel 30 miles in length under the main range of the Cascade Mountains. The building of this tunnel would enable the railway traffic between Puget Sound ports and the interior, which now has to be lifted vertically to an elevation of 2,500 to over 3,300 ft. in crossing the Cascade range by the present railway lines, to pass under the main range at an elevation of only 1,200 ft.

It is not merely the waste of the energy required to elevate this traffic, amounting to over 60,000 tons daily, to a height of 1,300 to 1,800 ft., which the tunnel would save. A much more important advantage, as General Chittenden points out in a graphic manner, is the elimination of the expense and risk involved in the maintenance of the large mileage of steep grades on the present railway lines across the mountains. The extent to which this huge mountain barrier hinders commerce and intercourse between the great fertile agricultural section on the eastern side of the mountains and the commercial centers on the coast, is hardly realized in the East.

Perhaps the most striking illustration of the advantages of the proposed tunnel route over the present mountain lines is the statement that the time of passenger trains would be reduced, between the east side and the west side of the mountains, from the present schedule time of 3 hours to 40 minutes, and the time of freight trains from 10 hours to 1½ hours.

The estimated cost of the proposed tunnel and approaches is $50,000,000, and this in itself a few years ago would have been sufficient to compel the dismissal of the project as chimerical. At the present day, however, railways are investing sums in the improvement of their facilities which would have staggered the imagination of financiers a quarter century ago. Announcement has just been made that the Great Northern Railway Co. proposes to expend in this very region probably a third of this amount to convert its lines from steam to electric traction, encouraged thereto doubtless by the success of the very large investment for the same purpose made by the Chicago, Milwaukee & St. Paul on its lines in Montana and Idaho.

Among other notable instances in recent years of heavy outlay for reconstruction of existing railways, are the building of the Central Pacific Ry. across Great Salt Lake to avoid the heavy grades over Promontory point, the work done by the Union Pacific in the improvement of its main line in Wyoming, and on the eastern side of the continent the two great pieces of reconstruction work undertaken by the Lackawanna R.R. to improve its main line in western New Jersey and eastern Pennsylvania.

When any of these large works of railway reconstruction are compared with the Cascade tunnel project, it is at once evident that what each of them accomplished in the improvement of grades and alignment is insignificant compared with the advantages which would result from this great tunnel enterprise. By way of illustration, take the Rogers Pass tunnel now nearly completed on the Canadian Pacific Ry. This work has involved the building of 18 miles of new railway line and a 5-mile tunnel. The summit elevation is reduced 540 ft. and the length of snow sheds from about 5 miles to less than 1 mile, but the maximum grade on the line is still 2.2%, and of course the maximum train load that can be hauled is unchanged. To effect this improvement the Canadian Pacific has deemed it worth while to carry out work involving a total expense of probably not less than $8,000,000, while the traffic affected is only that of a single railway line.

In comparison with this the 30-mile Cascade tunnel projected by General Chittenden would lower the summit elevation on the Great Northern Ry. 2,166 ft.; would save 48 miles of distance on its line to Tacoma; would reduce the maximum grade from 2.2% to 0.6%; and would eliminate curvature amounting to 6,855°. Most important of all, the tunnel would be available not for the traffic of a single railway, but for the traffic of all the railways terminating on Puget Sound.

In his paper in this issue General Chittenden briefly outlines the computations which indicate that the proposed tunnel would pay a large return on its cost. Of course, for a complete determination, the matter would have to be gone into in far more detail than is possible within the limitations of space in a technical journal. Such rough comparisons as that suggested above, however, and similar ones which any engineer can make for himself, as well as the figures given by General Chittenden, indicate that the traffic benefits resulting from the tunnel would yield an ample return on its cost.

To understand this, it must be borne in mind that the tunnel would be used almost wholly for through traffic, and this means of course that the traffic through it would be concentrated in very long trains. The Chicago, Milwaukee & St. Paul on its electrified lines across Montana and Idaho is handling freight trains weighing 3,000 to 3,500 tons behind the tender on grades up to 2%. On the Cascade tunnel line, with its maximum grade of only 0.6% and its freedom from sharp curvature, there should be no difficulty whatever in handling trains of this length or greater. Passenger trains through the tunnel would be chiefly the through transcontinental express trains. Eventually some local traffic between the east side and west side of the mountain may develop, but is never likely to become considerable. Operating through this tunnel on the absolute block system, with its light grades and with its long tangents, trains could safely be spaced much closer together than they are on the present outside lines over the mountains.

Another factor of great importance in considering the capacity of such a tunnel is that it should be possible to operate it with an approximately uniform flow of traffic through the 24 hours of the day. On an ordinary railway, the traffic has often as sharp peak loads during the 24-hour period as the load curve of an electric-lighting station. Such load peaks are necessary in handling local passenger and suburban traffic, and to a considerable extent in local freight traffic. They are not necessary, however, in handling through traffic. The Chicago, Milwaukee & St. Paul, in installing electric operation on its Idaho and Montana division, put in operation, probably for the first time in the history of American railroading, the plan of so distributing its train movements as to give an approximately uniform train movement throughout the day. It was necessary to do this in order to purchase electric power at a favorable figure,

and in the movement of the through traffic, which constitutes the chief business of the line, no great difficulty appears to have been found in putting the system into operation.

It is self-evident that where traffic can be thus equally distributed, the capacity of a double-track railway is enormous. With trains spaced no closer together than 10 minutes and uniform train movement through the 24 hours, 144 trains per day each way can be moved. Taking in connection with this figure the enormous tonnage of freight now handled in a single train, it is evident that the traffic capacity of the Cascade tunnel would be ample to take care of all the business tributary to it for as long as can be foreseen. Furthermore, that traffic promises to be enough to make the tunnel profitable.

Some questions may be raised as to the practicability of successfully operating a tunnel of such unprecedented length, although such questions will be raised by laymen rather than engineers. If it is practicable to operate the Simplon tunnel, 12 miles long under the Alps, which has now been in use for a dozen years, it would be practicable to operate a 30-mile tunnel under the Cascades.

Ventilation need present no more difficulty with the longer tunnel than with the shorter. On the Cascade tunnel there will doubtless be at least two intermediate shafts which can be used for ventilation as well as for construction purposes, and there is abundance of water power going to waste to provide forced ventilation if that were necessary. It is likely that when the traffic became sufficiently dense to make the question of ventilation important, then natural ventilation would result through the heat developed by the electric motors in the tunnel, which would cause the ventilating shafts to act like huge chimneys. In the cool climate of Washington, the air drawn in would always be at low temperature.

Train movements need offer no more difficulties in a 30-mile tunnel than in a 12-mile tunnel. General Chittenden's estimate in fact provides for sidings at intervals along the tunnel line to enable a disabled car or locomotive to be got out of the way temporarily without blocking the main line for any great length of time.

General Chittenden's paper is not only interesting from its review of the possibilities of the Cascade tunnel, but because it calls attention anew to the possibility of very long tunnels to improve railway operating conditions elsewhere. Up to the present time electric traction on steam railways has had its chief application in the operation of city terminal lines and in the operation of existing tunnels where the smoke from steam locomotives became seriously objectionable. It has hardly as yet been realized outside the engineering profession that the electric locomotive in combination with the present day possibilities in fast and economical tunnel driving has shown a way whereby radical reconstruction could be undertaken on the summit divisions of some main line railways with the prospects, at least, of large profits.

The advances in tunneling practice, too, have given a different basis for computing problems of railway relocation involving the use of long tunnels. The next decade or two, therefore, may witness not alone the realization of General Chittenden's great scheme, but of the driving of a long tunnel by the Pennsylvania to lower the summit of its main line across the Alleghenies, from its present elevation of about 2,200 ft.; or the Lackawanna or the Lehigh Valley may undertake a long tunnel to save part of the long climb now necessary to lift the anthracite coal from the Wyoming Valley over the mountains on its way to markets at tidewater.

Letters to the Editor

Concrete Buildings Are Free from Depreciation

Sir—Referring to the comparative costs of factory buildings of standard mill construction and of reinforced concrete, published in your issue of Nov. 9, p. 884, the writer from long experience in constructing both types of buildings would say that in general, a slow-burning mill construction building can compete with a reinforced-concrete building when the floor loads are light and the spans are short. With heavy loading and long spans on the other hand, the reinforced-concrete building has a decided advantage.

The question of comparative costs is also dependent on the number of skilled contractors available for reinforced-concrete construction in the locality as well as the restrictions of union labor.

A great many insurance companies do not make the difference in rating between slow-burning construction and absolutely fireproof construction that should be made. Many owners have spoken to the writer about this matter saying that they can not see why insurance men rail at the American public for building burnable buildings when they make no inducement in insurance rates which will compensate an owner for the increased expense of a non-burnable building. A properly designed and properly constructed reinforced-concrete building, however, is not only fireproof, but is subject to little or no depreciation. On the other hand, a slow-burning mill construction building does depreciate with time, and the depreciation will more than wipe out the difference in first cost in ten years.

ERNEST MCCULLOUGH,
Fireproof Construction Bureau,
Portland Cement Association.

Chicago, Ill., October 19, 1916.

Land Surveying in Texas

Sir—J. M. Howe's article on "Land Surveying in Texas," in *Engineering News*, of Oct. 19, arouses memories of rough surveys in my native state, where my father was for some years in the General Land Office at Austin. There he had charge of and issued state patents on surveys, filed with so-called land script. Subsequently, as a

member of the firm of Booth, Duval & Creuzbaur, he surveyed millions of acres of wild lands in more or less extended expeditions.

The Federal Government had no lands in Texas; and as Mr. Howe states, there were many misfits and vacancies between the old Spanish and other liberal grants located to cover the most valuable ground irrespective of sectional layout. Large areas were found between lines run from bases at opposite points of the compass; and as he says, the rough assumption of magnetic variation seldom allowed surveys to close on parallel lines. In one instance my father filed on 2,700 acres of exceedingly rich bottom land on the Colorado River (good for two bales of cotton to the acre, without fertilizer, for 50 years) in a case of this kind, where surveys had been run, I believe, from the Houston base, and surveys from the northerly base had been supposed to close and leave no vacancy.

In my early boyhood, as a volunteer, I have dragged chain on an 8-mi. compass course, run to locate the corner of an old Spanish league, where we carried our line over a precipice by the simple expedient of rolling a log over the top and resuming chaining at this dropped log after a wide detour to reach the bottom. On the other hand, I have a lithograph of a survey by R. Creuzbaur, April, 1855, in which I take a great pride. The high class of work done, with local magnetic variation and complete notes, is fully illustrated in this plat of the Maxmillian survey. On one side there was a typical wedge-shaped vacancy, 10,000 yd. in length filed upon and still owned by the surveyor's estate.

R. W. CREUZBAUR,
Consulting Engineer.

New York City, Oct. 27, 1916.

Definitions of Sewerage and Sewage-Disposal Terms

Sir—The report of the Committee on Sewerage and Sewage Disposal of the Sanitary Section of the American Public Health Association, dealing with definitions, quotations from which appear in your issue of Nov. 2, represents a work of great value and one deserving of high appreciation among sanitary engineers. The subject is one also that will benefit to an unusual degree by complete discussion, and to this end the following suggestions are offered:

Cage Screen—There would seem to be no advantage in restricting this name to a screen composed of bars or rods. The term might better be used to define the form of screen regardless of the screening element.

Hydrolytic Tank—As defined by the committee, this becomes a generic term including septic, Travis, Imhoff and other tanks of like nature. While this is not the usual use of the term, it is certainly desirable to have such a generic term. In the interests of precision, however, "biolytic" is to be preferred to hydrolytic. The latter means "a decomposition brought about by water" (Encyclopedia Britannica). Such a reaction is illustrated in the inversion of cane sugar. While the term biolytic, in the corresponding sense, has not yet reached the dictionary, its similar meaning, "decomposition brought about by living matter," is obvious and definitive.

Colloidal Matter—The definition given is approximately accurately for what the chemist knows as "colloidal solution." Although no single property is in general sufficient to distinguish colloidal solution from suspensions, on the one hand, and true solution, on the other, the committee has adopted as criteria the two simplest and most comprehensive points of distinction—namely, non-settleability and non-diffusibility respectively. Colloidal matter, according to W. Ostwald, includes in addition to matter in colloidal solution the so-called hydrogels, or settleable colloids, as seen in a concentrated aqueous boiled-starch suspension. This separates into two layers, the true colloidal solution above and the gel below. Unfortunately for the work of definition this class of substance is common in sewage.

The writer has always questioned the advisability of using the term colloids in sewage chemistry. It is a difficult term to use even under the conditions of experimental laboratory work and impossible of being used with even approximate accuracy in connection with sewage. The partial definition of the committee (and this is certainly the best that can be done) illustrates the impracticability of the term, since the diffusion test is hardly capable of routine laboratory application. Were the test practicable, it would serve to define a class of matter the definition of which has little or no practical bearing. Matter in neither colloidal nor in true solution will separate spontaneously by gravity, and both kinds of matter are capable of precipitation through chemical reaction. Colloidal solution may well be classed therefore as true solution so far as sewage is concerned.

Similarly, hydro-gels, being capable of sedimentation, may be classed with settleable solids without sacrificing any information of value. The writer is determining settleable solids for various periods of sedimentation from 15 min. to 24 hr. by reading the approximate volumes of sediment in a conical settling jar. The relation between volume and dry weight is determined once for all by comparison of settleable and non-settleable solids determined in the usual manner. For reasons similar to those urged above he believes that filtration, which separates the sewage matter into two artificial groups having no relation to purification processes, the line of demarcation in addition being indefinite according to the character of filtering medium used, furnishes no useful information; and results showing matter in solution and in suspension, respectively, by this classification should not be reported.

Disinfection—It would seem more satisfactory to allow this word its full meaning so as to include ordinary water purification, for example, among the disinfecting agents, for sand filtration of either water or sewage is as truly a disinfecting process as is the use of bleaching powder. The writer has used this conception in his lectures for some years and has always qualified that which the committee defines, as chemical disinfection. There is also to be considered (although not in sewage work) disinfection by such agents as ultra-violet light, which is truly disinfection, but would not be included within the committee's definition. The same remarks apply to the term sterilization.

In anticipation of criticism from others of the term trickling filter, the writer wishes to register his approval of this term as being most descriptive of the essential feature of this type of treatment. He also wishes to commend the committee for the satisfactory completion of a somewhat arduous task.

EARLE B. PHELPS.

United States Public Health Service,
Washington, D. C., Nov. 7, 1916.

Fire or Explosion Wrecks Part of Concrete Warehouse

A fire in and around the seven-story reinforced-concrete storage warehouse of Mullen & Buckley, in Far Rockaway, N. Y., in the early morning of Nov. 10, damaged the contents of that building and, either by direct contact or through the medium of an explosion, destroyed at least two floor panels and wrecked one large column with adjoining beams and girders. The building was ordered vacated during the progress of the fire for fear it would collapse and is still barred to general visitors. The wrecked portions and the fire débris prevent a full exploration of the structure but enough could be seen on Nov. 13, when the accompanying views were taken, to show a most interesting condition.

The warehouse is a seven-story and basement building, 52x90 ft. in plan, of the usual column, girder and slab construction. It is divided by the columns into two cross panels, 15 ft. 6 in. by 26 ft. and into five main lengthwise panels and these in turn are subdivided by transverse beams into 7 ft. 9 in. by 26 ft. panels. The columns are square and reinforced with straight rods tied together only with wire spacers; the beams and girders with straight rods and attached stirrups; the slabs with wire mesh. The walls are of concrete, and the fire stops, around the one stairway and the elevator shaft, are of hollow tile. These openings are well guarded with automatic closing fire-proof doors and the window openings are provided with casement steel sash and wire glass. There were no sprinklers. The contents were of the usual storage-warehouse type, some stored in fireproof rooms, but mostly in the open unpartitioned floor. A considerable amount of furniture and furniture material increased the combustibility of the contents. The gravel concrete appears to be of acceptable quality.

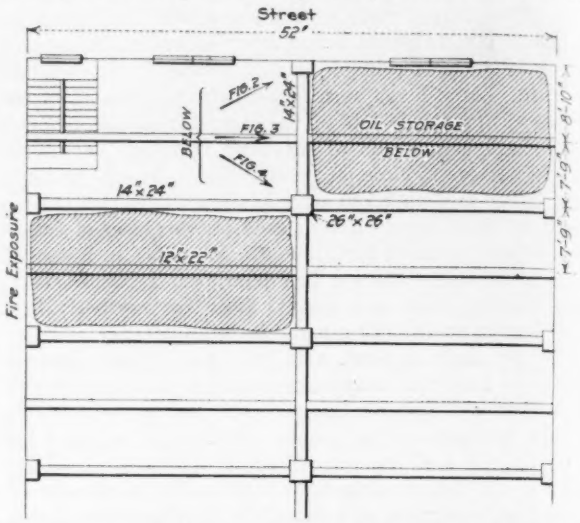


FIG. 1. FOURTH-FLOOR PLAN OF REAR OF WAREHOUSE

FIG. 2. REAR WALL END OF THIRD-FLOOR BAY WHERE COLLAPSE TOOK PLACE
Outer wall on left. Oil-storage room in rear

FIG. 3. LOOKING TOWARD OIL-STORAGE BAY WITH COLLAPSED FLOOR
The cross-beam is the beam common to views in Figs. 2 and 4. Outer wall at left. Collapsed column at right

On the west side of the building it was connected to a three-story frame structure used as a cabinet shop by the firm owning the warehouse and the two buildings were in communication on three floors by openings guarded with automatic closing fireproof doors. On this same side were also some windows (steel sash and wire glass) above the frame building. Other windows inside the frame building were blocked off with interior brick walls.

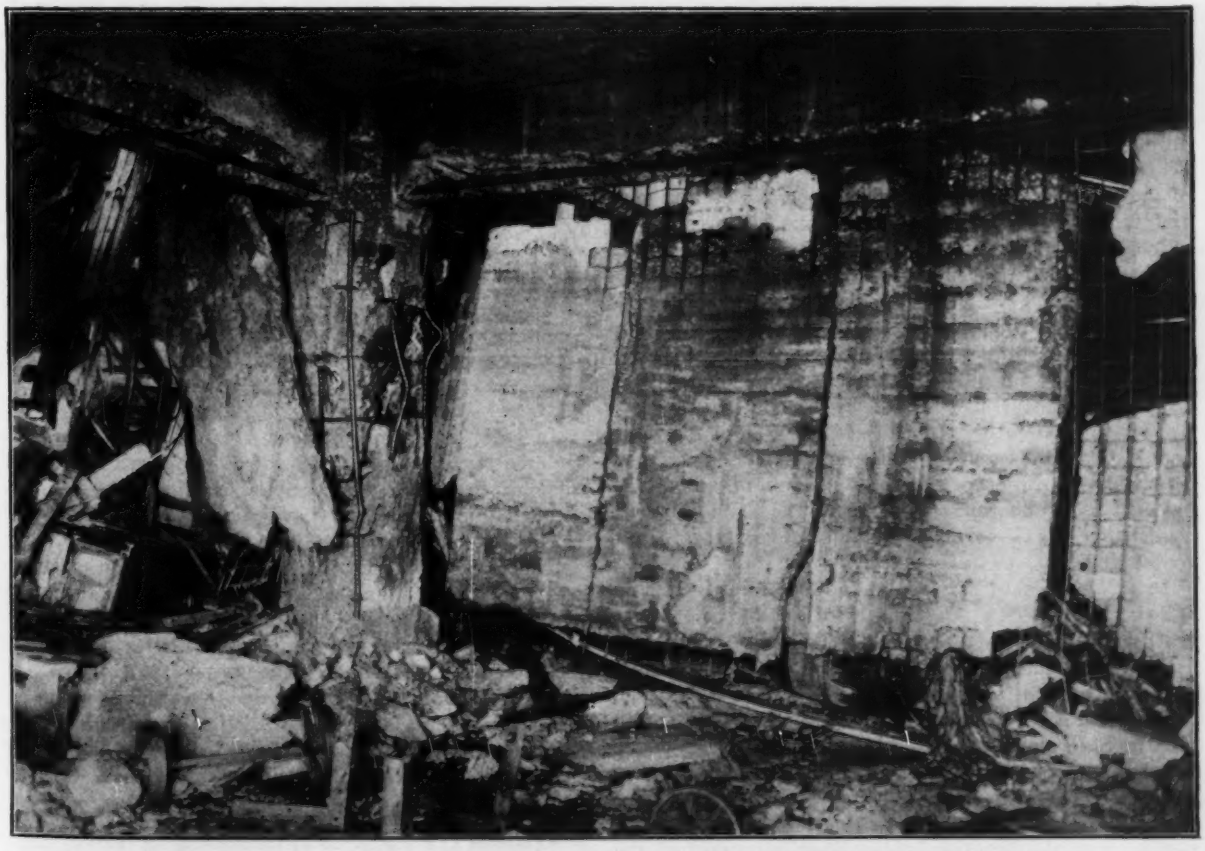


FIG. 4. FRACTURED COLUMN ON THIRD FLOOR AND FALLEN SLAB FROM FOURTH FLOOR
Left-hand beam is continuation of beam in Fig. 2

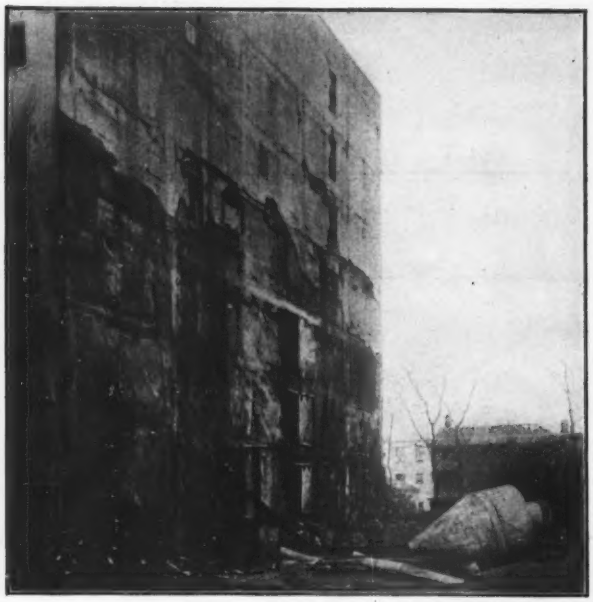


FIG. 5. EXPOSED WALL OF WAREHOUSE
Dark area marks location of destroyed frame building. Note doors connecting two buildings and that upper (third floor) door is missing

The progress of the fire is at present uncertain. It started in the frame shop about midnight and in the high wind prevailing soon brought a great number of fire companies who were mainly occupied in preventing the spread of the flames to an adjoining thickly settled frame building area. Apparently the possibility of fire in the adjoining concrete building was not seriously considered until flames appeared on some of the floors of that building. Just where these flames entered is not known. It may be noted from Fig. 5 that the two lower firedoors on the exposed side are open but in place; inside evidence shows that there was no entry of flame at either of these openings. The third-floor door, however, is gone and fallen floors inside do not permit of investigation of conditions there. It is possible that this door was open and that the fire entered here. Other possible points of entry are windows, either on the street fronts or on the exposed side, which may have been open or subjected to such heat as to break the wire glass.

The fire was not put out until the frame shop and an adjoining residence had been destroyed and the concrete warehouse apparently gutted. An inspection of the warehouse later showed that the contents' destruction was very scattered. In several of the upper floors hardly any damage had been done and in no place was there complete combustion or evidence of very high temperature. Horizontal separation was very good.

In one section of one floor abnormal conditions prevailed. This section is on the third floor at the north, that is the back, end of the building. Here the northeast bay was separated by tile partitions and was used as a storage room for inflammable oils and, it is reported, for celluloid sheets. Above this the floor was loaded with gas ranges in crates and adjoining that with screen doors. The bay west of the oil room was open and only sparsely filled with combustible material.

The views, Figs. 2 to 4, show the present condition of that part of the building. The northeast panel of the fourth floor (over the oil room) has collapsed and let down the load of gas ranges onto the third floor which is still intact. This is shown in the background of Fig. 3. The main column, 26x26-in. square with eight ¾-in. vertical bars, shown in the background of Fig. 4, has cracked clear through diagonally and has had the 1½ to 2 in. concrete surfacing nearly completely broken off the steel, which has bulged outward to accommodate the 2 or 3 in. drop in the column. The cross girder, at the right in Fig. 4, is also damaged to the extent of exposing the steel but has not apparently sagged. The fourth-floor bay just south of this girder—only lightly loaded—has also collapsed onto the third floor which still holds. The longitudinal girder, common to the backgrounds of Figs. 2, 3 and 4, has sagged appreciably and cracked as shown and its wall column support has lost most of the face concrete though no reinforcement is disclosed. No further pronounced structural damage is visible in the building, but complete exploration may reveal minor faults.

Until further examination is possible it is hardly profitable to conjecture on what happened at this end of the building. It appears at present as though the fire entered from the front of the building toward the rear of the third floor and raised the oil and celluloid there to an explosive temperature, the ensuing explosion blowing down the partitions and subjecting the ceiling and column to such intense heat as to cause local failure and subsequent collapse. This fire was probably soon extinguished because the wooden crates now in what was the oil room are hardly scorched, which also may indicate that the collapse occurred subsequent to the intense heat in that compartment. The failure of the diagonally opposite bay (see diagram) must have been due to the sudden drop of the column and consequent shock to the floor-beam as neither above nor below are evidences of much heat.

The building department became fearful of the safety of the building and are now considering its future disposition. An examination of the other parts and the apparent stability of the third floor under the falling fourth floor would seem to indicate that the fear is unfounded and that, like the Edison buildings at West Orange, the warehouse can cheaply and readily be restored to a safe condition.

Water Losses in City Systems*

By F. A. Barbour†

In entirely metered systems, or in systems where the metered services exceed 85% of all the services, at least 20% of the water furnished is, on the average, unaccounted for. The question arises as to whether we should be content with such a condition.

This 20% loss is not based on a comparison of pump records with the water sold, but on the figures furnished by water-works superintendents as to the water unaccounted for in their systems. These figures presumably include corrections for such items as pump slippage. It would seem that a loss of 20%, due to leakage from mains and services or to under-registration of meters, which undoubtedly represents the best conditions, is sufficiently sizable to justify careful consideration of possible remedies.

*Abstract of a discussion at the meeting of the New England Water-Works Association, Boston, Mass., Nov. 8.

†Consulting Engineer, Boston, Mass.

We all know that the total unaccounted-for water in unmetered systems is enormous; presumably we all agree that metering is the great remedy, and yet, as reported by the United States Department of Commerce, only 40% of the services are metered in 201 cities, containing 26,000,000 people and having an average per capita consumption of 139 gal. per day. This total loss is not the subject of our immediate discussion, but as a means of calling attention to present standards of management a few figures may not be amiss.

The total population in the United States supplied with water from public works may be taken, for present purposes, at 50 million people, and the average amount of water furnished per day at 100 gal. per capita. The total water supplied daily by public works is, therefore, in round figures, 5,000 million gallons. It is probably a safe statement that 50% of this quantity is wasted, and assuming the actual cost of furnishing the useless 2,500 million gallons to be $25 per million gallons—and this is an extremely low figure—the cost per day of the water wasted is equal to $62,500 or $22,800,000 per year, which is equal to the interest on an investment of $500,000,000. Figured in this rough way, the results do not speak very well for our present-day standard of management of water systems. If it should be answered that it is not practicable to prevent this loss, a reasonable reply would be that at least we should know more about its causes than apparently is known at the present time.

As already stated, metering is the great means of reducing the total waste on which the previous figures are based, but there remains the fact that in the fully metered systems, on the average, at least 20% of the water furnished is unaccounted for, and probably if more accurate data were available, this percentage would be shown to be materially greater. The late Emil Kuichling estimated 2,500 to 3,000 gal. per mile per day as the leakage from well-laid mains; the late Dexter Brackett estimated a leakage of from 10,000 to 15,000 gal. per day in the Metropolitan District; and John R. Freeman stated that his best guess of the underground leakage in New York was from 25 to 35 gal. per day per capita, equal to from 20,000 to 30,000 gal. per day per mile of pipe.

In six cities, with 95% of the services metered, reported by Brackett in 1904, 36% of the water was unaccounted for, equal to an average loss of 11,300 gal. per mile of pipe. James H. Fuertes, in the 1906 Report to the Merchants Association of New York, presented statistics from 13 cities, where on the average 82% of the services were metered, which showed that 31% of the supply was unaccounted for, equivalent to approximately 18,000 gal. per mile of pipe.

What part of these losses are chargeable to the mains is unknown, but from the results of such leakage surveys as have been made, and from the reported actual losses discovered in some cities, it is probable that 7,500 gal. per mile of pipe per day is a conservative estimate of the water lost by leakage from the 60,000 mi. of mains now in use in the public supplies of this country, or 450 million gallons daily. At $25 per million gallons, this is equal to a daily loss of $11,250 or $411,000 per year, or the interest on $100,000,000.

In the light of this economic waste it would appear that the subject of leakage from mains is worthy of careful consideration. The Committee on Water Consumption of the New England Water-Works Association reported in 1913 that "in general it may be said that if in a well-metered system the water unaccounted for does not exceed 25% of the total pumpage, the practice is good." Doubtless this should be interpreted to mean that a 25% loss is good compared with the average present practice, but is it good compared with the standard which should be set up in this age when we hear so much about conservation? Should we complacently accept a loss of 25% as inevitable, and if this loss cannot reasonably be much reduced in the systems already constructed, what about the possibility of better methods of construction in the pipe to be laid in the future?

It is, of course, out of the question to consider the relaying of present systems or to do more than make leakage surveys and check the larger losses, but in the light of present knowledge, is it not time to seriously undertake an analysis of the causes responsible for the present large percentage of water unaccounted for? If these losses are chargeable to under-registration of meters, then this should be definitely made known, and consideration given to the possibility of developing more sensitive or more accurate measuring apparatus.

Are we taking sufficient care in testing pipe for water tightness when laid? About 60% of those replying to the circular of the Committee stated that the pipe is tested when laid, and all but six make the test before backfilling. In the writer's experience, testing before backfilling in the ordinary work of laying distribution systems is rare, and it is undoubtedly from the practice of simply turning on the water without any test that a considerable part of the present leakage develops. The standard of those who test, as indicated by the replies received, is "absolute tightness," but in the writer's experience this result is not easy to obtain, and only possible where the joints are gone over several times after the pressure is applied.

Where pipes are backfilled before testing, the allowable leakage, as determined by such test, has varied greatly in different specifications. John H. Gregory at Columbus made the limit 500 gal. per inch-mile per day. At Akron 200 gal. per inch-mile per day was specified, while actual results at Akron showed about 70 gal. per inch-mile per day. E. G. Bradbury, in his paper before the New England Water-Works Association in 1914, proposed 100 gal. per inch-mile per day as a reasonable standard for the allowable leakage in testing after backfilling. He figured that the difference between 500 and 100 gal. per inch-mile per day, estimating the cost of the water at $25 per million gallons, would equal a yearly cost for water lost in a city of 100,000 people, of $5,256; or in other words, the city could afford to spend $470 per mile in order to save 400 gal. of leakage per inch-mile per day.

Again, are the present jointing methods the best qualified to maintain tightness after periods of use? Who knows anything about the comparative leakage when laid and after several years?

In this latter connection the history of the work at Grandview, Ohio, is of interest. As reported by Mr. Bradbury, the supply is measured by a tested meter and all service pipes are metered. The 5.5 mi. of pipe originally laid were tested before backfilling and the leakage before any connections were made amounted to 31 gal. per inch-mile per day, or in other words, the system was practically watertight. Subsequently 0.9 mi. of additional mains were laid, and gradually in the four years since the date

of original construction the services have increased to the present number of 205. Either by less careful work in the extension or by depreciation of the original work, or by under-registration of the gradually increasing number of meters, the unaccounted-for water has increased until at the present time it averages about 150 gal. per inch-mile per day.

An interesting feature in connection with these records is that the unaccounted-for water, based on three years' observations, averages 60 gal. per inch-mile per day during the six months from October to April and 213 gal. during the six months from April to October. In other words, the records indicate in this system that the unaccounted-for water is three times as great during the summer as during the winter months. Whether some local explanation can be found for this result, or whether it is a reasonable result of temperature changes is not known, but data from other systems showing the unaccounted-for water during periods of varying temperature would be of considerable interest.

Any information of definite tests of leakage from observation of mains after periods of use or of the effect of temperature on leakage or the results of tests of leakage from lead joints with different shapes of bell and spigot or of other types of joints will be of value to the New England Water-Works Association Committee on Leakage, and it is hoped that if any one has such information he will forward it to the Committee.

News of the Engineering World

Water-Supply Losses Discussed; Meter Rates Adopted

The regular monthly meeting of the New England Water-Works Association, held in Boston, Mass., Nov. 8, was devoted chiefly to the report of the committee on meter rates, water loss by leakage, non-registration of meters and otherwise. The aggregate amount of and the economic features of water waste caused by leakage and non-registration of water meters were clearly set forth by F. A. Barbour.

The report of the committee on meter rates and water loss, presented by Allen Hazen, consulting engineer, New York City, chairman, contained a great deal of new and interesting matter. In a way it was a discussion of Mr. Barbour's paper on leakage, presented at the recent Portland convention of the association. The committee has collected statistics as to the use and loss of water, and allied matter, from a number of completely metered systems.

Returns were received from 35 water-works systems. These systems had 524,364 services and 520,719 meters. The total daily output was about 300 million gallons or 575 gal. per service. Of this quantity about 140 gal. per service was not accounted for. The majority of these systems measured their total output by venturi meters.

The amount of water unaccounted for averaged 27% of the total output. For the several systems the water not accounted for ranged from 12 to 49%. The loss of water was attributed: (1) Leakage from mains; (2) leakage from service-pipes between mains and meters; (3) under-registration of meters; (4) water used for various purposes, not metered or estimated, as flushing sewers, etc.

About half of the total number of services passed less than 100 gal. per day; and there are few meters which register a steady flow of as little as 100 gal. per day. Therefore it is possible for much water to be wasted by plumbing leaks which will not be metered. The larger sized meters pass much larger amounts without registration. About 86.6% of all the meters in the systems studied were ⅝-in. size.

The report of the committee gives much data on the classification of different consumers by quantity of water used, and on the quantity of water delivered by meters of various sizes.

The committee decided that with complete metering and with meters carefully tested it is possible to reduce the unaccounted-for water to 20% of the total output, or to from 60 to 80 gal. per service.

As to service charges where meters are installed the committee decided that they should be based in a general way on their carrying capacities. A table of relative capacities of the different sizes of meters is included in the report. The report of the committee embodying this charge for a ⅝-in. meter was adopted: (1) A charge of 10% of the average investment of the works in the service pipe and meter; (2) a charge of $1 per annum for reading meters, billing and collecting; (3) a charge of $2 per annum for the probable value of unregistered water.

The form of meter rate schedule presented to the Association by the committee and printed in the "Journal" of the Association, Vol. 30, p. 361, was adopted. The committee believes this form of schedule flexible enough for all water-works. The committee made no recommendations for or against a uniform or sliding scale of rates. Mr. Hazen, however, personally favored a sliding scale in which the following elements would be considered: (1) Cost of supplying 1,000 gal. (should be uniform); (2) service charge (more for larger sizes); (3) distribution cost (less for larger sizes of services).

Minneapolis Wins Filter Suit

After years of litigation and defeat in the lower court, the City of Minneapolis has established its right, and the right of other cities as well, to the use of the central control of operating valves and also to the use of a screen between the sand and the gravel in mechanical water filters. The United States Circuit Court of Appeals declares that central control is not only "common, familiar practice in other branches of industry" but was covered in patent No. 564,474, dated July 21, 1896, on central closing of bulkheads, doors, hatches, etc., on ship board. The patent claim for a screen between filter sand and gravel was anticipated, the court holds,

by a half dozen patents granted to Hyatt, Peterson, Weiderman, and Hefel years ago. Of the claim that the screen prevented the gravel from rising up into the sand, the court declares that it does not think that "rises to the dignity of invention. It would naturally occur to a person ordinarily familiar with such work." The decree of the lower court is ordered reversed and the bill dismissed.

The decision of the lower court was handed down in August, 1915. The two contested claims were printed in *Engineering News* of Sept. 9, 1915. These claims were claim 1 of patent 649,410 on central control of filter operations, and claim 14 of patent 649,411 on the use of a screen between the sand and gravel, granted to Ira H. Jewell on May 8, 1900. In the earlier decision there was also considered patent 649,409 for a combination of a filtered-water chamber beneath a filter bed with columns supporting the bed from the bottom of the chamber and means for forcing the water up from the chamber through the bed. This patent was thrown out by the lower court. Comment on these and some other recent patent decisions may be found in the editorial columns of this issue.

Reorganizing Public Roads and Rural Engineering Office

In accordance with the terms of the Federal Aid to Road Construction Act, the Secretary of Agriculture has delegated the responsibility of supervising the Federal aid roads to the Office of Public Roads and Rural Engineering. To enable the office to carry out this responsibility, a new organization was put into effect on Nov. 1, which is shown in graphical form herewith.

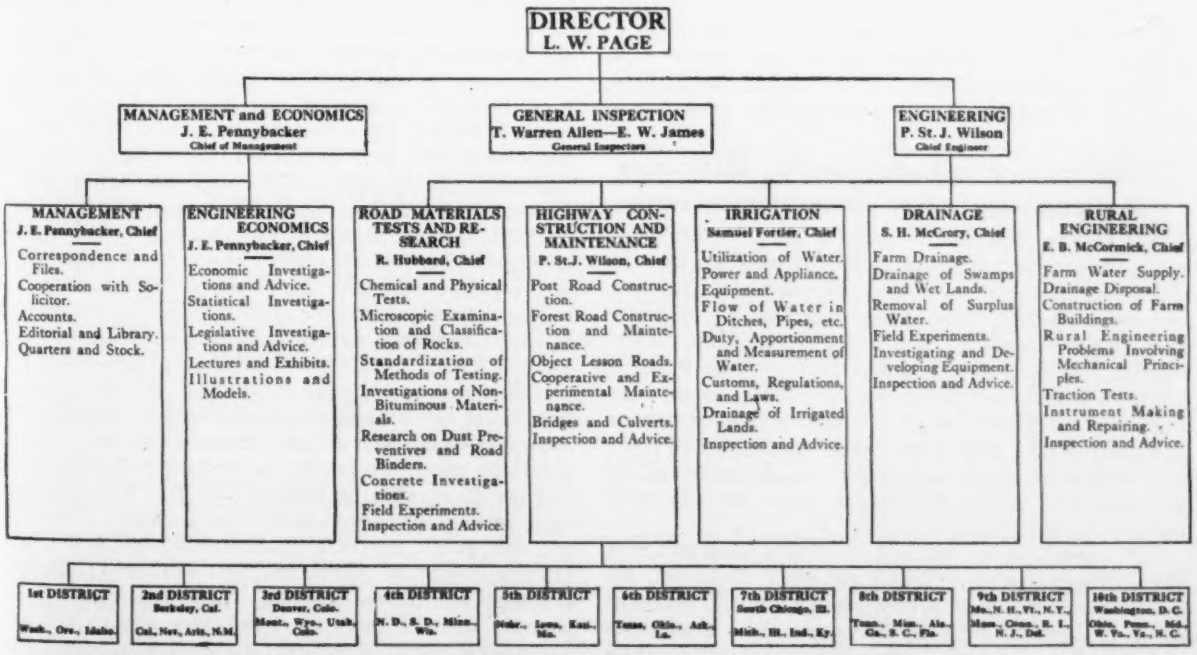
As the chart makes clear, the two main branches of the office are: (1) Engineering and (2) Management and Economics. The Chief Engineer, P. E. St. J. Wilson, has charge of the Engineering branch, reporting directly to the Director of the Office, Logan W. Page, and becoming Acting Director in Mr. Page's absence. The heads of the divisions of Rural Engineering, Drainage, Irrigation, and Road Materials report directly to Mr. Wilson, and he himself has charge of the work of object-lesson road construction and maintenance investigations authorized in the Agricultural Appropriation Act, and also of the Federal aid roadwork, including the building of roads in forest reservations.

The ten field districts established, as shown on the chart, will each be in charge of a district engineer to look after the Federal aid roadwork in his territory, and also such object-lesson roads and experimental work as may be built in his district. The organization also provides, as shown by the chart, for two general inspectors whose duty it will be to inspect field operations upon instructions from the director, reporting directly to him.

Concrete Dock Patent Upheld in Court of Appeals

United States Patent No. 1,089,405, granted to W. S. Ferguson and assigned to J. D. Carey, for a "reinforced-concrete dock or pier," was upheld on Oct. 13, 1916, in a decision handed down by Judges Warrington, Knappen and Sessions, of the United States Court of Appeals, sixth circuit. The case before them was the Detroit Iron and Steel Co. against James D. Carey and was a review of the decision of July 17, 1915, by Judge Tuttle, of the United States District Court, in which he decided that the company infringed the Ferguson patent in the construction of a reinforced-concrete dock at Detroit, Mich.

The Ferguson patent, now owned and exploited by the Cleveland Dock and Engineering Co., Cleveland, Ohio, of which Mr. Carey is president, is essentially on an L-shaped reinforced-concrete wall extending out over a waterway, with the outer end supported on spaced piles and the inner end on or alongside of a tight wall of



PLAN OF ORGANIZATION OF THE OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING, DEPARTMENT OF AGRICULTURE

sheetpiling. The patent was granted Mar. 10, 1914, but the patentee swore the invention back to July 10, 1906.

The lower court decided, first, that the dock wall in suit was an infringement of the Ferguson design, and, second, that that design was not anticipated either by previous patents or structures. The Court of Appeals affirmed this decision and furthermore stated that even though every element in the design was old—a contention of the plaintiff in appeal—"invention would still exist if by the combination of these old elements there is produced a new and useful result, or if the result is effected in a new and materially better way, as in the case here."

Primary Unit for Marine Terminal at Bayonne

On Nov. 14 the engineers for the proposed new marine and industrial terminal at Bayonne, N. J., presented the recommendations for the first unit of the terminal to the Board of Commissioners of Bayonne. As described in *Engineering News*, July 13, 1916, p. 90, the terminal is to be the joint project of the city and of a company headed by Irving T. Bush, and is to resemble the famous Bush terminal in Brooklyn in that it will contain warehouses and factories, with ample railway entrance and pier accommodation. The first unit is described by the engineers as follows:

> The installation will provide on upper New York Bay dockage for 30 modern freight ships in addition to lighters, barges, etc., a railroad yard with facilities for classifying and assembling freight with a capacity of 1,000 cars, a ferry terminal for a Bayonne-Manhattan vehicular and passenger ferry, four miles of bulkhead platform, 1,350,000 sq.ft. of one-story bulkhead sheds and 7,770,000 cu.ft. of second- and third-story bulkhead sheds, and over 200 acres of land for industrial buildings together with trolley and highway connections, railroad sidings, float bridges for railroad cars, etc.
>
> The total estimated cost of this installation is $7,234,545, of which $2,121,673 is for dredging, bulkheading and reclamation, and $5,112,872 for the other facilities. These estimates provide for interest on the cost during construction and provide for 35 ft. depth of water.

These plans are embodied in a detailed report which has been prepared under the immediate direction of B. F. Cresson, Jr., Chief Engineer of the New Jersey State Board of Commerce and Navigation, and F. Van Z. Lane, Engineer of the Bayonne Chamber of Commerce.

Electrical Engineers Discuss Appraisal and Depreciation

The regular November meeting of the American Institute of Electrical Engineers, in New York City, Nov. 10, was given up to a discussion of the subject of appraisals and depreciation. The opening paper was by Philander Betts, Chief Engineer, New Jersey Public Utility Commission. It was entitled "Effect of Recent Decisions on Work of Inventory and Appraisal." This was an argument that appraisals must be sufficiently detailed so as to give their results with a very small percentage of error, and cited a few cases leading up to a disclosure of the necessity of classifying property as to use and degree of use in various classes of service.

The second paper, entitled "Continuous Inventories, Their Preparation and Value," was by H. E. Carver, Assistant Engineer, New Jersey Public Utilities Commission. It disclosed first the many uses for a continuous inventory in addition to the benefits secured by operating companies in promoting efficient operation and keeping down unit costs of doing work—the gains being in having data always available for answering complaints as to charges, being prepared for cases involving increases on account of increased cost of labor and material, possibility of immediate presentation of property value for basis of security issues, possibility of checking accruing renewal funds, having immediately available data for satisfying labor investigations, ability to make more accurate distribution of charges, etc. It was found that all the requirements for accomplishing the running inventory resided in the work-order system generally used by companies under various terms like "authorizations for expenditure." A single additional step was required: An allocation of the cost of each piece of construction or property acquired had to be made in detail when the work was completed. Specific forms were exhibited to illustrate how such a system was built up.

The third paper, entitled "Growth and Depreciation," was by Julian Loebenstein, Junior Engineer, Public Service Commission for the First District, State of New York. This was a study of the effect of growth of a utility plant in capacity as to its effect on depreciation and renewals (assuming that the various pieces of equipment followed perfectly definite and fixed lengths of life). It appeared from graphical analysis that the condition of the property at any time was dependent upon the rate of growth as well as the amount of maintenance. The author argued that in rate cases a return should be allowed on reserves for renewals, provided that depreciated value of the property was also employed. The sum of renewal reserve and depreciated value gives the original value, which many desire to employ.

The oral discussion on these papers was meager.

Kittitas Irrigation Project

Life has been put into the irrigation project of the Kittitas Reclamation District embracing about 70,000 acres of irrigable land near Ellensburg, Wash. It is reported that Twohy Bros. Co., of Portland, Ore., has an option extending to Dec. 1 for the purchase of bonds and construction of the proposed works. The district was formed in 1912. Surveys and plans were made at an expense of about $60,000 and a bond issue of $5,000,000 was authorized. For various reasons it appears to have been impossible to dispose of the bonds and so the project has remained dormant. R. H. Thompson, of Seattle, and J. R. Holman, of Portland, have made a report on the project, and have recommended changes in the plans which it is expected will make a material saving.

The water supply for the project would be from storage in the Government reservoirs on the headwaters of the Yakima River. Water would be diverted from the river near Easton to and through about 92 mi. of canal. Special features of the project are several siphons across creeks and cañons tributary to the Yakima River, and a large siphon by which the north branch canal would cross the Yakima River under a head of 295 ft. The estimated cubic yardage of various sorts is as follows: Earth, 1,683,500; gravel, 896,000; hardpan, 407,300; loose rock, 128,800; cemented gravel, 292,000; solid rock, 198,900; concrete, all classes, 95,000. Steel requirements (in pounds) are: Structural, 1,745,300; pipe, 1,113,400; reinforcing bars, 2,557,000; pipe bands, 2,690,800. About 3,400,000 ft. b.m. of lumber would also be required.

Results of Fire-Prevention Work in some of the larger cities in the country are summarized by the National Board of Fire Underwriters in a recent bulletin. New York City had 1,010 fewer fires in 1915 than in 1914, and its aggregate fire losses were $2,460,000 less. Chicago in 1915 had 1,238 fewer fires than in 1914, and its fire-loss total was reduced $1,006,000. Cincinnati had 430 fewer fires in 1915 than in 1914, and its losses were reduced nearly 50%. Milwaukee had 682 fewer fires in 1915 than in 1914 and reduced its fire loss $291,000. All the cities above named have been doing effective work for fire prevention.

Union Pacific Improvements to cost several million dollars were announced in a press dispatch from Omaha, Nov. 9, quoting Judge Lovett, Chairman of the Board, as stating that a new tunnel would be driven under Sherman Summit, Wyoming, where the road crosses the Continental divide. Official information has since been furnished that the proposed work involves the completion of the double tracking over Sherman hill between Hermosa and Buford, about 12 mi., which will involve a new 1,800-ft. tunnel parallel and adjacent to the present Sherman tunnel. While the proposed work is under consideration, it has not yet been definitely decided on.

Progress on the Four East River Tunnels under construction for the New York Rapid Transit System was reported by the Public Service Commission under date of Nov. 13. The tunnel which is being driven between Old Slip, Manhattan, and Clark St., Brooklyn, is the farthest advanced. The headings of the north tube for this tunnel are now in solid rock and only 190 ft. apart. It is expected these headings will meet about Dec. 1. The headings of the south tube for the same tunnel are about 300 ft. apart. The tunnel farthest south, that between Whitehall St., Manhattan, and Montague St., Brooklyn, has its headings about 1,000 ft. apart, and it is expected they will be joined about May 1, 1917. For the two northern tunnels, which are to extend under the river from 14th St. and 60th St., Manhattan, the shafts are now being sunk.

PERSONALS

Frank M. Williams, M. Am. Soc. C. E., has been re-elected State Engineer of New York on the Republican ticket.

F. L. Beal, Jun. Am. Soc. C. E., Valuation Engineer of the Louisiana & Arkansas Ry., Stamps, Ark., has been promoted to be General Manager of the company.

Malcolm H. Crump has resigned as County Road Engineer of Warren County, Kentucky, effective Jan. 1, 1917, and will devote his whole time to private practice.

A. P. Wyman, formerly Assistant Engineer of the Maine Central R.R., Portland, Maine, has been appointed Civil Engineer of the Texas Steamship Co., Bath, Maine.

Edwin G. Foster, Assistant Engineer of the Buffalo, Rochester & Pittsburgh Ry., has been promoted to be Valuation Engineer, with headquarters at Rochester, N. Y.

C. G. Lunday, Superintendent of the Louisiana & Arkansas Ry., Stamps, Ark., has been promoted to be General Superintendent in charge of operation and maintenance.

J. L. Lee, Assoc. M. Am. Soc. C. E., of San Francisco, Calif., has been appointed Valuation Engineer of the Sierra Railway Co. of California, with headquarters at Jamestown, Calif.

Winfield A. Haller, M. Am. Inst. E. E., formerly with Sanderson & Porter, New York City, has organized the firm of Haller & Krumbhaar, engineers and contractors, New York City.

E. K. Morse, M. Am. Soc. C. E., whose appointment as Rapid Transit Commissioner of Pittsburgh, Penn., was noted in last week's issue, has had his appointment confirmed by the city council.

Arthur T. Clark, Assistant Engineer with Robert E. Horton, Consulting Hydraulic Engineer, Albany, N. Y., has been appointed Resident Engineer in charge of the new water-supply of Herkimer, N. Y.

Mason D. Pratt, M. Am. Soc. C. E., has resigned as Chief Engineer of the United Railways & Electric Co., Baltimore, Md., to resume private practice as a consulting engineer, with offices in Roland Park, Md.

John Hulst, Chief Mechanical Engineer of the Carnegie Steel Co., Pittsburgh, Penn., has been appointed Consulting Engineer of the United States Steel Corporation, with headquarters at New York City.

B. S. Thayer, Assoc. M. Am. Soc. C. E., recently with the Inspiration Consolidated Copper Co., Miami, Ariz., is now with engineering staff of the Tallassee Power Co., Alcoa, Tenn., on the construction of the Cheoah dam.

Clarence W. Marsh has established an office at 101 Park Ave., New York City, for private practice in plant design and construction of industrial, chemical and electro-chemical enterprises and for engineering investigations.

R. G. Clyne, M. Am. Soc. M. E., has resigned as Mechanical Engineer of the Western Cartridge Co., East Alton, Ill., to engage in business on his own account, designing and building special machinery. His headquarters will be in St. Louis, Mo.

Sidney Dillon, Mechanical Engineer of the Edgar Thomson Works of the United States Steel Corporation, has been made Chief Mechanical Engineer of the Carnegie Steel Co., Pittsburgh, Penn., succeeding John Hulst, promoted, as noted elsewhere.

C. P. Collins, Assoc. M. Am. Soc. C. E., whose resignation as Sanitary Engineer of Johnstown, Penn., was noted in these columns of Nov. 2, p. 866, has adjusted the disagreement between the city council and his department and has withdrawn his resignation.

J. R. Sherman, Assoc. M. Am. Soc. C. E., has resigned as Assistant Engineer, United States Reclamation Service, Meadow Creek, Wash., to become Engineer in charge of construction of a large dam near Rancagua, Chile, for the Braden Copper Co.

B. A. Brennan, formerly Contract Manager of the Westinghouse Machine Co. of Pittsburgh, recently Vice-President of the Mercantile Trust Co., St. Louis, Mo., has been elected President of the Citizens Co., Baltimore, Md. The Citizens Co., Inc., is an investment banking institution.

Edwin Higgins, M. Am. Inst. M. E., Chief Mine Inspector of California, has resigned to become Assistant Safety and Efficiency Engineer of a group of important mines in California. He is temporarily succeeded by **H. M. Wolfin,** M. Am. Inst. M. E., Mining Engineer, United States Bureau of Mines and the California Industrial Accident Commission.

Norman L. Warford, recently in charge of the Powdered Coal Department of the Anaconda Copper Mining Co., Anaconda, Mont., is now Engineer in charge of construction of the Powdered Coal Engineering & Equipment Co., Chicago, Ill. Mr. Warford installed at Anaconda what is claimed to be the largest powdered coal plant in the United States. It utilizes approximately 1,000 tons of pulverized coal daily.

Walter C. Allen, Assoc. Am. Inst. E. E., Electrical Engineer of the District of Columbia, Washington, D. C., has resigned to become Executive Secretary of the District Public Utilities Commission, succeeding Maj. Julian L. Schley, who has been assigned to the United States Engineer Office at New Orleans, La. Mr. Allen is a graduate of the University of California and has been in the service of the District for the last 22 years.

Carl J. Rhodin, M. Am. Soc. C. E., recently Civil-Hydraulic Engineer, San Francisco office of the J. G. White Engineering Corporation, has opened offices in the Alaska Commercial Bldg., San Francisco, Calif., for private practice. He was graduated from the Royal Technical University of Stockholm, Sweden, in 1900, and came to this country two years later. He was engaged in bridge and structural work with Eastern engineering firms until 1906, when he went to San Francisco. For a short time he was with the California State Highway Department. He has been with the J. G. White Co. since 1911.

Melville Fiske Clements, M. Am. Soc. C. E., whose appointment as Bridge Engineer of the Northern Pacific Ry. was noted in these columns of last week, was born in Iowa in 1875. He was graduated from the State University of Iowa in 1899, and the same year began his railway experience with the Burlington, Cedar Rapids & Northern Ry. Subsequently he spent four years with the Chicago, Rock Island & Pacific Ry. and a year as Engineer with the Clinton Bridge and Iron Works. He joined the Northern Pacific engineering staff in 1907 as an Assistant Engineer and recently has been in charge of grade-crossing elimination work at Spokane, Wash.

Edgar F. Robinson, M. Am. Soc. C. E., formerly Chief Engineer of the Buffalo, Rochester & Pittsburgh Ry., has been made General Manager. He was born at Earlington, Ky., in 1874 and was graduated from Rose Polytechnic Institute in 1894. His railway experience began in 1895 as a masonry inspector with the Cleveland, Cincinnati, Chicago & St. Louis Ry. He was with the maintenance-of-way departments of several Middle West railways until 1901 when he was made Superintendent of Maintenance of the Butte, Anaconda & Pacific Ry., at Anaconda, Mont. He returned East in 1902 to become Engineer of Track of the Buffalo, Rochester & Pittsburgh Ry., and in 1907 he was made Chief Engineer of the company.

OBITUARY

John T. Williams, a well known civil engineer of California, died Nov. 1, at Quincy, Plumas County, from pneumonia. He was Chief Engineer in charge of construction of the Indian Valley R.R., a branch of the Western Pacific R.R.

George R. Brown, formerly General Superintendent of the Fall Brook Coal Company's R.R., and the originator of "Brown's discipline," died at his home in Rochester, N. Y., Nov. 5. His system of discipline of trainmen and other railway employees, without resorting to suspensions, was widely adopted in the nineties.

ENGINEERING SOCIETIES

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 16-17. Annual meeting in New York City. Secy., D. H. Cox, 29 W. 39th St.

ELECTRIC POWER CLUB.
Nov. 15-17. Annual meeting in Hot Springs, Va. Secy., C. H. Roth, 1410 W. Adams St., Chicago.

KANSAS GOOD ROADS ASSOCIATION.
Nov. 16-17. Annual meeting in Lawrence Society headquarters in Kansas City.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.
Nov. 16. Annual meeting in Atlanta, Ga. Secy., A. J. Merrill, P. O. Box 1205, Atlanta.

CITY MANAGERS' ASSOCIATION.
Nov. 21-23. Convention in Springfield, Mass. O. E. Carr, Niagara Falls, N. Y.

NATIONAL MUNICIPAL LEAGUE.
Nov. 23-25. Annual meeting in Springfield, Mass. Secy., C. R. Woodruff, 705 North American Building, Philadelphia.

American Society of Mechanical Engineers—The excursion to New London, Conn., to inspect the plant of the Electric Boat Co. and to witness an exhibition of United States Navy submarines, carried out under the auspices of the American Society of Mechanical Engineers, Nov. 11, was highly successful from the point of view of attendance. There were fully 1,600 engineers from New York and various New England cities—a crowd which proved beyond the capacity of the hotels and larger than could be accommodated on the vessels available to take the visitors to the site of the submarine exhibition. Some of the excursionists were unable to get aboard the naval vessels, and a large number of those who did get aboard the vessels were unable to visit the Electric Boat Co. plant. Besides members of the American Society of Mechanical Engineers, members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the Boston Society of Civil Engineers, the Brooklyn Engineers Club, the New York Engineers Club, the Providence Engineering Society, the Philadelphia Engineers Club, the Engineering Alumni and students of Brooklyn Polytechnic Institute, Brown University, Columbia University, Massachusetts Institute of Technology, New York University, Stevens Institute of Technology, Worcester Polytechnic Institute, Yale University and other organizations of engineers were present.

Appliances and Materials

Carbon Grounding Cone

An improved low-resistance nonmetallic electrode for use as an electric grounding-line terminal, and given the trade name "Burn-Boston Carbon Cone," is being put out by Hickey & Schneider, 61 Broadway, New York City. The device is a long cone formed by a hard carbon pencil, 1.5x23 in., surrounded by a thick porous moisture-absorbing carbonaceous jacket. A copper lug and lead wire are sealed into the top.

* * *

Multiple-Disk Road Roller

An improved design of road roller has just been marketed by S. E. Finley, of Atlanta, after having been experimentally developed in connection with the "Finley Method" of laying bituminous-bound stone roads. One is shown in the accompanying view. Two sizes are made; the larger has eighteen 54-in. cast-iron wheels 1 in. wide with 2½ in. clear separation. The holes in the wheel hubs are 1 in. larger than the axle, so that the roller adjusts itself to the crown. The weight of the roller can be adjusted by loading sand or gravel into a long box across the rear. When rolling on a hard smooth surface the load is about 325 lb. per sq.in. (1x1-in. contact for each wheel). The scheme of this type of roller is to have the wheels penetrate the loose stone as spread, packing it at the

FINLEY'S MULTIPLE-DISK ROAD ROLLER

bottom first and gradually consolidating the whole course. The larger machine sells for $600. The smaller weighs 5,000 lb., has 42-in. wheels and sells for $500.

* * *

Self-Aligning Lighting Fixtures

A special suspension fixture for factory lamps—one that always hangs vertical—is being made by the Central Electric Co., of Chicago. The important part is a cast-iron canopy fitting a standard 4-in. outlet box and inclosing a ball-and-socket joint that permits a fixture to swing through a 25° angle. This canopy and joint replace the usual stud, crowfoot and box cover and cost about the same as the replaced equipment.

* * *

Small Gasoline Industrial Truck

A new type of gasoline truck and tractor—for freight handling at railway terminals, docks, warehouses, etc., and for transferring material in manufacturing establishments—has been brought out by the Milwaukee Locomotive Manufacturing Co., of Milwaukee, Wis. A steel frame supports a 48x78-in. loading platform; this can be tilted about one end to expose the engine and transmission. The truck steers by the front wheels which are attached to the front axle by steering knuckles as in automobile construction. There is a vertical steering wheel at the rear, where the operator rides on a platform. The wheels are of disk construction and are rubber tired. Power is furnished by a 10-hp. four-cylinder four-

GASOLINE INDUSTRIAL TRUCK AND TRACTOR

cycle vertical engine running at 1,000 r.p.m., and is transmitted by a bevel-gear differential and external drive axles. There is an electric starter. The transmission (selective type with multiple-disk clutch) permits speeds of 2.4, 4 and 7.6 miles per hour forward and 2 miles reverse. Internal expanding brakes act on drums on the drive wheels and are set by a hand lever and by the clutch-pedal release. The engine is cooled by pump circulation through the jackets and to a honeycomb radiator.